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HAZARD ANALYSIS OF POLLUTION ABATEMENT TECHNIQUES. VOLUME I.

R. A. Knudsen

Hercules, Incorporated

Prepared for:

Picatinny Arsenal

June 1974

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FINAL REPORT

HAZARD ANALYSIS OF POLLUTION ABATEMENT TECHNIQUES

VOLUME I OF III

Prepared by

Hercules Incorporated
Allegany Ballistics Laboratory
Cumberland, Maryland

Prepared for

Picatinny Arsenal
Dover, New Jersey

Contract No. DAAA21-73-C-0771

Report No. A0262-520-03-007

HERC [illegible]. 75-43

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I. INTRODUCTION

This is the final report for the "Hazard Analysis of Pollution Abatement Techniques" submitted to Picatinny Arsenal, Dover, New Jersey, under Contract No. DAAA21-73-C-0771.

As part of the modernization of munitions manufacturing and loading facilities, Picatinny Arsenal has been assigned the task of abating pollution stemming from various processes with the objective of meeting standards established by regulatory agencies. Hercules Incorporated at Allegany Ballistics Laboratory (ABL) has performed a hazards analysis of four (4) proposed pollution abatement techniques under this contract.

U. S. Army Armament Command ARMCOM Regulation No. AR-50-21, formerly 385-22, requirements[1] outline the criteria for establishing and implementing Hazards Analysis Techniques for concept, development, and production phases for new facilities at all USAARMCOM installations. The approach used by ABL in assuring that all pollution abatement facilities studied meet these requirements stems from a practical quantitative approach[2] to the assessment of system operations through the use of the Hazards Evaluation and Risk Control (HERC) program. This approach is quantitative in nature and utilizes engineering measurements of both the in-process energy and the response of processed material to this energy to determine the severity of hazards (i.e., fires or explosions). These data, coupled with a computer simulation using a logic model of the system as the format, provide the probability that such hazards occur in the systems as designed.

The pollution abatement processes listed below were analyzed for potential hazards under this contract:

A. ADSORPTION SYSTEMS

1. Treatment of TNT Pink Water by Carbon Adsorption

The analysis of this system was based on the existing plant at Iowa Army Ammunition Plant (IAAP). (The analysis does not include the carbon regeneration process.)

2. Molecular Sieve Adsorption of Nitric Acid Tail-Gas

The basis of this analysis is the treatment of off-gases from a 55 ton/day nitric acid plant at Holston Army Ammunition Plant (HAAP). The system is as described in a letter to Picatinny Arsenal from Union Carbide Corporation[4].

B. INCINERATION SYSTEMS

1. Fluidized Bed Incineration of Explosives and Propellants

The fluidized bed to be constructed at Picatinny Arsenal provided the basis for this analysis.

2. Incineration of Contaminated Inert Waste

The prototype contaminated waste incinerator, as described in a final report by Uniroyal, Inc.,[5] and located at Joliet Army Ammunition Plant (JAAP), was analyzed.

One result of this study is the preparation of a design manual, (presented as Volume II of this report), "Manual of Hazard Evaluation Criteria for Implementing Pollution Abatement Processes at Various Installations." This manual is intended to provide design criteria (from a hazard viewpoint) for the operation of pollution abatement processes applicable to the systems presented. It indicates areas of concern that would be expected to lead to personnel injury or equipment damage (Categories I-IV type events as per 385-22).

During the course of this contract, the molecular sieve process to be studied was changed and rotary kiln incinerator at Radford Army Ammunition Plant (RAAP) was deleted from the study. The molecular sieve analysis was changed to a system which treated nitric acid tail-gas fumes rather than one which treated TNT nitrator off-gases as originally requested. A subsequent report by RAAP[3] has shown the potential hazards in the TNT nitrator molecular sieve process. Consequently, tail-gas from the nitric acid plant was analyzed in this study. The rotary kiln incinerator was deleted because a hazards analysis had previously been conducted.[20]

II. SUMMARY

A. OBJECTIVE

The objective of this contract was to establish standards for evaluation of the hazard potentials of two types of pollution abatement processes, adsorption and incineration systems, associated with U. S. Army Munitions facilities. Two adsorption systems and two incineration systems were studied.

In fulfilling the objectives of this study, a manual for these specific pollution abatement systems is being published for future distribution to Government-Owned Contractor Operated (GOCO) locations. It includes a detailed hazard analysis of the subject systems in the pilot stage and a list of additional hazards analyses required to convert the processes to production scale in compliance with ARMCOM 385-22 (AR-50-31) and MIL-STD-882.

B. METHODS AND ANALYSIS CRITERIA

The pollution abatement systems have been analyzed utilizing the proven HERC techniques as described in the Introduction. These analyses focus attention on estimating the chance of occurrence of a fire or explosion which results in equipment damage and/or personnel injury. Design and operating criteria are recommended for the pollution abatement processes. Normal operations, startup/shutdown, emergency shutdown, and maintenance operations which could lead to the undesired fire or explosion were considered.

Failures described for the various systems which had a probability of incident of $\geq 10^{-6}$ per hour are shown in Table II-I. The selection of 10^{-6} probability is based on the hourly average death rate for each worker in the United States of 1.6×10^{-6} as shown in the 1973 Accident Facts Publication, published by the National Safety Council (Chicago, Illinois). Thus, a criterion death rate of 10^{-6}/hour assures that the hazard to employees is not greater than that applicable to the average worker in the United States.

C. RESULTS AND CONCLUSIONS

1. Summary of Results for each System

a. Carbon Adsorption of TNT Pink Water - The analysis of the seven principal process units in the carbon adsorption system identified nine (9) sequences, (see Table II-I), which have probabilities equal to or greater than 10^{-6} for a fire or explosion occurring and damaging equipment and killing or injuring personnel. Five of these sequences result from maintenance and involve welding operations when the equipment has not been sufficiently cleaned, so that a dry layer of TNT remains on the equipment. Another sequence involves a maintenance operation in the filter where frictional initiation is caused by rubbing of a tool over the contaminated equipment. Two impact initiation modes present hazards during startup/shutdown operations when filling or emptying the diatomaceous earth filters, or when filling or emptying the carbon columns. Frictional initiation modes can occur in the filter due to movement of diatomaceous earth over a sufficiently dry TNT layer.

b. Molecular Sieve Adsorption of HNO_3 Tail-Gas - Analysis of the nine principal process units in the molecular sieve system for adsorption of nitric acid tail-gas showed no probability greater than 10^{-9} for incident which could cause a fire or explosion to occur and result in equipment damage and personnel death or injury. Thus, no unacceptable hazard was identified.

c. Fluidized Bed Incineration of Propellants or Explosives - Analysis of the ten principal process units used in the fluidized bed incineration of propellants or explosives indicated six sequences (see Table II-I) which have probabilities equal to or greater than 10^{-6} for the undesired event. Three concern the pilot gas operation in the burner. The assumption is made that a system failure in the feed line for pilot gas can transport sufficient quantity of pilot gas to the burner, which would be ignited by one of three initiation sources: (1) normally occurring fire in the burner, (2) normally occurring fire in the preheater, or (3) residual heat from an extinguished fire. A similar situation exists in the fuel oil burner. Each of these situations has a probability of 10^{-4}.

d. Incineration of Contaminated Inert Wastes - Analysis of the four principal process units in the incineration of contaminated inert wastes indicated six sequences (see Table II-I) for the undesired event which have a probability equal to or greater than 10^{-6}. These were for contaminants having threshold initiation levels similar to M1 or N5 propellant. For those similar to TNT, only three sequences were identified. All but one occurred during maintenance operations in the hopper and ram charger and had probabilities of occurrence of 10^{-4}. The explosive or propellant layer was not removed prior to maintenance for these sequences. Two maintenance operations involved welding in each unit. The other two maintenance operations involving sliding friction depended on the type of material in the layer. The non-maintenance initiation source occurred in the ram charger where the heat from the furnace ignited the explosive or propellant layer.

The probability of delivery of too much natural gas or fuel oil to the incinerator was considered to be at least 10^{-7} for this system due to the multiplicity of burners in the contaminated waste incinerator.

2. Design and Operating Criteria

The recommendations listed below should be followed in the design and operation of the systems studied.

a. Carbon Adsorption of TNT Pink Water - A careful check for dry TNT should be made before any maintenance operation. Any dry TNT layer must be removed before commencing said operation. In addition, contaminated diatomaceous earth should not be handled in a dry condition. Spent carbon, as well as spent earth, should be thoroughly wet down prior to the removal from the process.

b. Molecular Sieve Adsorption of HNO_3 Tail-Gas - No changes in design and operating criteria are required based on the 10^{-6} probability guidelines.

c. Fluidized Bed Incineration of Propellants or Explosion - Flow limiters should be installed in the fuel oil feed line to the burner and the pilot gas feed line to the burner so that a line failure could not transport sufficient fuel to the burner to cause a fire or explosion.

d. Incineration of Contaminated Inert Wastes - A careful check should be made before any maintenance operation to assure removal of any propellant or explosives layer before beginning the maintenance. In addition, the loading door interlock should not be opened until the temperature is less than about 100°C.

3. Future Work

The following items are suggested as areas where future work would be beneficial to the overall safety of adsorption or incineration pollution abatement systems.

a. In the Carbon Adsorption System, the process of regeneration of spend carbon should be the subject of a complete hazards analysis since the carbon will contain adsorbed explosive. Of particular concern are thermal modes of initiation in process where heat might be used to regenerate the carbon. If any consideration is given to salvaging or regenerating the spent diatomaceous earth, this process should be analyzed. Preliminary material response testing indicated that spent diatomaceous earth is sensitive to initiation when dry. Additional tests should be conducted on this material in various states of contamination with explosive and wetness. If the system is used with other explosives, both spent carbon and spent earth should be tested to characterize the hazards involved in handling these materials.

b. In the Molecular Sieve System, a complete hazards analysis should be performed if the system is to be used for other than treatment of nitric acid tail-gas.

c. In the Fluidized Bed Incinerator System, an area which should be subjected to hazards analysis (if it has not been previously analyzed) is the slurry preparation process which was not within the scope of this program. This process would be expected to be particularly subject to potential hazards if it involves size reduction of explosives or propellants.

c. In the Contaminated Inert Waste Incineration System, it is planned to add an automatic feeding system. This system (conveyors) should be analyzed for potential hazards.

TABLE II-I

SUMMARY OF CRITICAL SEQUENCES

Sequence of events which could lead to fire in a unit with a probability of $>10^{-6}$

	Probability of Incident
System: Carbon Adsorption	
Unit: Carbon Adsorption Column	
1. Welding on carbon adsorption column when combustible layer present (Thermal)	10^{-6}
2. Movement of carbon impacts column wall when combustible layer present and surface not wet (Impact)	10^{-6}
Unit: Diatomite Filter	
1. Movement of Diatomite impacts filter vessel when flammable PEW present and surface is not wet (Impact)	10^{-3}
2. Maintenance man rubs tool over PEW layer (Friction)	10^{-6}
3. Diatomite moves over PEW layer (Friction)	10^{-6}
4. Welding on Diatomite filter when PEW layer present (Thermal)	10^{-3}
Unit: Circulating Pump	
1. Welding on circulating pump when PEW layer present (Thermal)	10^{-4}
Unit: Settling Tank	
1. Welding on tank when PEW present (Thermal)	10^{-5}
Unit: Sump Pump	
1. Welding on sump pump when PEW present (Thermal)	10^{-4}

TABLE II-I (Cont'd)

Sequence of events which could lead to fire in a unit with a probability of $>10^{-6}$

	Probability of Incident
System: Molecular Sieve System	
None	
System: Fluidized Bed Incinerator	
Unit: Burner	
1. There is a fire in adjacent unit when there is sufficient flammable fuel oil present.	10^{-4}
2. There is a normally occurring fire in the burner when there is sufficient flammable fuel oil present.	10^{-4}
3. There is residual heat in the burner when there is flammable fuel oil present.	10^{-4}
4. There is a fire in adjacent unit when there is sufficient pilot gas in burner.	10^{-4}
5. There is a normally occurring fire in the burner when there is sufficient pilot gas.	10^{-4}
6. There is residual heat present in burner when flammable pilot gas is present.	10^{-4}
System: Inert Waste Incinerator	
Unit: Hopper	
1. During maintenance, tool is rubbed over contaminated surface (Friction).	10^{-4}
2. Welding is performed on hopper when sufficient PEW Layer is present (Thermal).	10^{-4}
Unit: Charger	
1. During maintenance, tool rubs over contaminated surface.	10^{-4}

TABLE II-I (Cont'd)

Sequence of events which could lead to fire in a unit with a probability of $>10^{-6}$

	Probability of Incident
2. Welding is performed on charger when sufficient PEW layer exists.	10^{-4}
3. Fire in an adjacent unit when there is a sufficient PEW layer.	10^{-4}
4. Residual heat in charger when there is a sufficient PEW layer.	10^{-4}

III. DISCUSSION

A. METHODOLOGY

Hazards analyses were performed on four pollution abatement systems using the HERC technique previously described. These systems were, (1) carbon adsorption of TNT pink water, (2) molecular sieve adsorption of nitric acid plant tail-gas, (3) fluidized bed incineration of propellant or explosive material and (4) incineration of contaminated inert wastes.

Initial phases in this study included identification of potentially hazardous in-process materials and possible initiation modes, as well as development of a logic model for each process, and computer simulation of the logic models. The selection of potentially hazardous in-process materials is discussed, along with the potential initiation modes, under each abatement process. The development of the logic models and a brief description of the computer program used to simulate the logic model is presented in the Appendix with the logic models.

1. In-Process Potentials

In-process potentials were calculated whenever possible for each initiation source. Some potentials were not practical to calculate and were shown as being undefined although they were assumed to be sufficient to cause initiation when sufficient fuel is present. These potentials include: (a) electrical power discharge from faulty electrical tools, (b) faulty electrical instruments or controls, (c) faulty electrical process units, and (d) impact caused by loose parts vibration.

Other impact potentials were defined, such as dropping a bolt or a hand tool, or impacting tramp material in an operating blower. Calculations for these impact energies were based on data from Radford Army Ammunition Plant (RAAP)[6] and data at Allegany Ballistics Laboratory (ABL)[7]. The most severe in-process potential was reported when a choice existed.

Frictional in-process energies were assumed to be equal to at least the yield strength of the material of construction, and in some applications three times the yield strength was used. To be conservative, stainless steel was assumed when the material of the process unit was not known. It was estimated that stress loads could be applied at velocities of 2 ft/sec during maintenance. Velocities due to other sources were calculated for the equipment under consideration. In cases of gas particulate flow, gas velocity was used, as if there were no slip between gas and the particles it carried.

In-process energies due to thermal sources were based on the maximum expected temperatures. The maximum temperature attained during welding is approximately 3600°C. A similar temperature would be expected if a fire occurred in an adjacent unit. The maximum temperature assumed for overheated bearings is 1500°C (approximately the melting point of steel). The temperature for residual heat was assumed as the normal temperature for the operation, when appropriate. For an overheated electrical element, a temperature of 1177°C was based on data in the "Material Handbook" by Brady[8].

ESD ignition modes were classified under two basic categories. The first was human ESD, and its maximum energy, 0.015J[9], was considered as the in-process potential. The other was airveying material. The "rule of thumb" value, 0.025J, used by Palmer in his recent book[10] was assigned to any airveying material when no better data were available.

Impingement potentials were evaluated at the expected gas velocity. This is a conservative approach since the particle or tramp material velocity is always lower than the velocity of the gas which is propelling the solid material.

2. Safety Margin

The initiation safety margin calculated in this study is a ratio that defines the fraction that the threshold initiation energy is greater than the in-process potential. The definition is:

$$SM = \frac{(\text{material response}) - (\text{process potential})}{(\text{process potential})}$$

or $$SM = \frac{(\text{material response})}{(\text{process potential})} - 1$$

Safety margins have two purposes. They show where the immediate problems are that require further attention. For example, if a system analysis reveals that of ten potentially hazardous conditions, nine exhibit safety margin values greater than 100, and one has a safety margin of three, then obviously the effort should be directed towards this latter condition. The safety margin also provides a means for estimating the probability of occurrence of an event[7].

Analysis based on safety margin is conservative since maximum expected in-process potentials are used with minimum required ignition energies.

The conversion from safety margin to probability of initiation is shown in Table III-I. Different conversions exist for different initiation modes except that the conversions for impact and electrical modes are the same. It should be noted that the conversions provide a "best estimate" although they are not exact, e.g., for the frictional mode, a safety margin between four and eight gives a probability of initiation of 10^{-6}.

TABLE III-I

Safety Margin vs Probability of Initiation When Sufficient Fuel is Present

I. Frictional Mode

Safety Margin	Probability of Initiation
< 0	1.0
0	3×10^{-2}
1	2×10^{-4}
2-3	10^{-5}
4-8	10^{-6}
9	5×10^{-7}
> 9	10^{-7}

II. Impact or Electrical Mode (ESD)

Safety Margin	Probability of Initiation
< 0	1.0
0	3×10^{-2}
1	5×10^{-5}
2-3	10^{-6}
4-7	10^{-7}
8-19	10^{-8}
> 19	10^{-9}

III. Thermal Mode

Safety Margin	Probability of Initiation
< 0	1.0
0	3×10^{-2}
1	5×10^{-6}
2	10^{-7}
3	10^{-8}
4-6	10^{-9}
7-9	10^{-10}
$> 9, < 19$	10^{-11}
> 19	10^{-12}

IV. Impingement Mode

Safety Margin	Probability of Initiation
< 0	1.0
0	3×10^{-2}
1	5×10^{-12}
2	10^{-16}

3. Guidelines for Probabilities

It was previously stated that the purpose of this effort is the identification of potential hazards in the systems being analyzed. For this work, the hazard to be identified is any set of circumstances which may lead to the undesired event, "fire or explosion causes injury or death to personnel or damage to equipment." The existence of such a set of circumstances is probabilistic in nature, so the probability of occurrence of each element which contributes to potential hazard is assigned a numerical value in order to form a basis for the analysis.

The overall probability of occurrence of the undesired event is calculated as the product of three basic probabilities, ($P = P_E \times P_{CP} \times P_I$,) where

P = Overall probability of the undesired event.
P_E = Probability that an event will occur.
P_{CP} = Probability that combustible will be present.
P_I = Probability that an initiation stimulus of sufficient energy will occur.

(Refer to Figure III-1, page III-5, to see how these items are shown in the analysis fact sheets, which appear in Tables III-II through III-XXXI for the systems analyzed.)

Discussion of the assignment of values to the basic probabilities appears below.

The numerical value assigned to a probability cannot usually be assumed to be precise, since the assigned values are often the result of statistical treatment of test data or accumulated historical data from operations performed over a significant period of time or significant number of operation cycles. Since there are practical limitations on the accuracy of tests performed, and it is possible for historical data to be incomplete, or data may have been collected from operations or equipment similar to but not the same as that being considered in an analysis, the statistical treatment of data is usually biased in the direction of conservatism. The best values available to the analyst at the time the work was done were used in this analysis.

a. Probability that an event will occur

Each event considered is classified as normal or abnormal. Normal events are assigned a value of one for probability of occurrence. This applies to any event that occurs as a normal part of an operation.

Unusual events are those that do not occur in the normal process. The value of probability for unusual events is usually less than one. Examples of unusual events are mechanical and electrical failures and human failures. The preferred basis for assignment of probability values to these events is historical data. The probability is

Summary of Events Which Can Cause Fire in the Carbon Adsorption Column

PROCESS UNIT

POTENTIAL PROBLEM: (G3C)* i.e., Fire in Carbon Adsorption Column

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	†PROBABILITY	
1. Flammable TNT or Nitrobodies (G5A)*				10^{-6}	
				Y	Z
2. Initiation stimulus a. Impact (G3E)* 1. Maintenance	166 ft-lbs/in^2 (7/16" Bolt)	TNT 31.6 ft-lbs/in^2	TNT-0	1	10^{-4}

Potential initiation hazard and the quantitative analysis of the initiation stimulus

Combustible material present

Quantitative sensitivity of the combustible

Probability of the event occurring

Probability of initiation energy present

* Refers to specific gates in the Example Tree (FIGURE III-2)

† To determine probability of a fire, multiply the probability of a combustible being present, times Y, the probability of stimulus being of sufficient energy to cause initiation, times Z, the probability that the stimulus occurs.

FIGURE III-1

Example Table

(Hazard Analysis Summary)

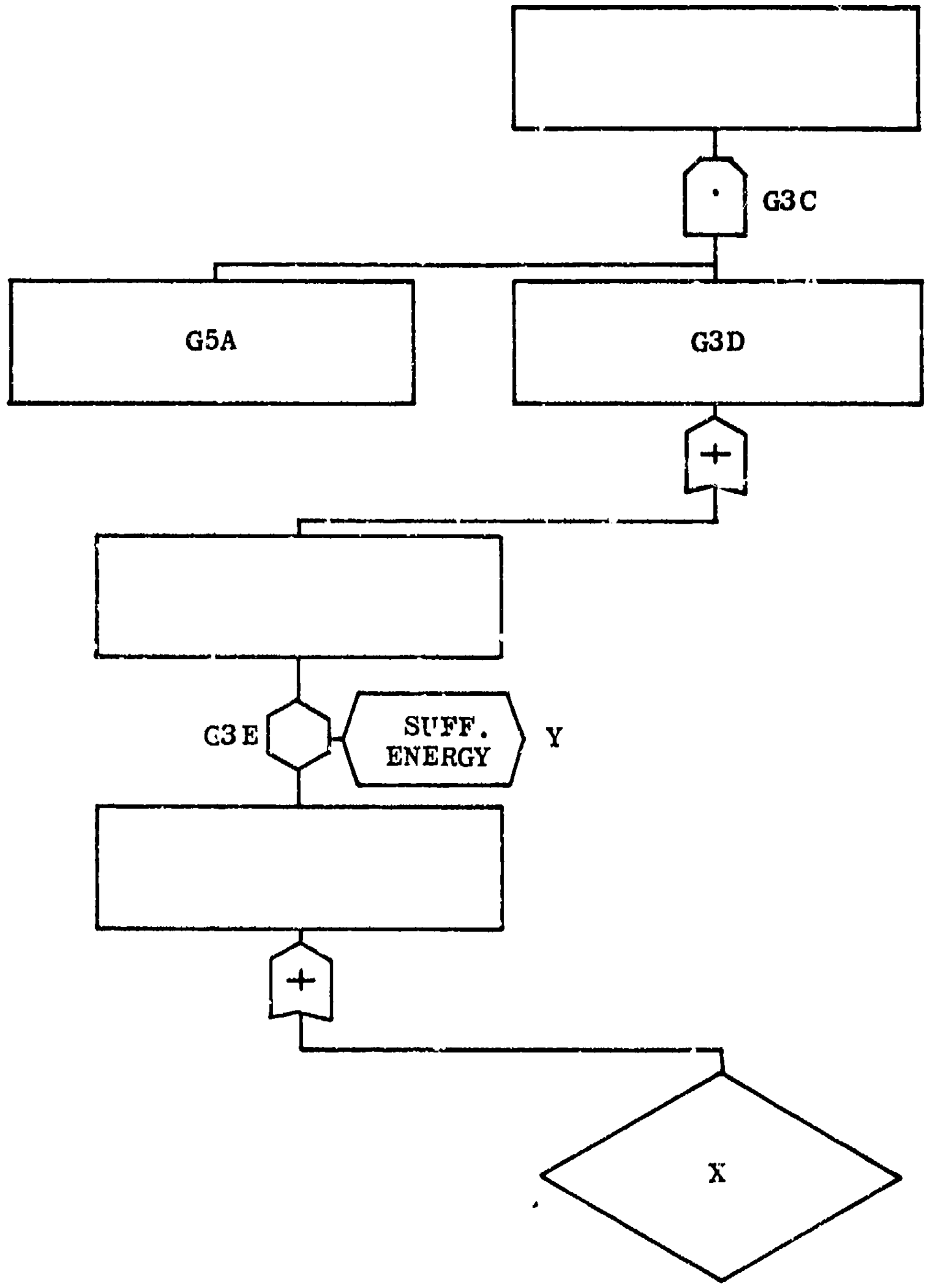

FIGURE III-2

Example Tree

(Logic Diagram)

calculated by dividing the number of failures observed by the number of hours of operation during which the failures occurred, or if the operation is cyclical, the number of observed failures is divided by the number of cycles of operation during which the failures occurred.

If historical data are not available, the probability value may be assigned on the basis of guidelines developed from other sources. Ground rules used to establish some of the event probabilities in this analysis are listed below:

(1) A probability of 10^{-3} is designated for events which occur due to procedural errors, such as the failure of an operator or maintenance man to follow a routine procedure. This value was established by examination of operating records for several Hercules plants for a "Zero Defects" program evaluation.

(2) A probability of 10^{-3} to 10^{-5} is applied to accidental situations resulting from human failure, with the specific value chosen dependent on factors such as operator experience, complexity of operation, or work area situation (crowded, cluttered, noisy, hot, etc.).

(3) A probability of 10^{-4} is assigned to both mechanical and electrical failures. The data used to establish these is from FARADA publications, using data for several types of mechanical and electrical equipment.

b. Probability that combustible is present

The presence of combustible or fuel, may be normal or abnormal for a specific equipment or operation. If its presence is normal, the probability value assigned is one, but if it is abnormal, the probability value is usually less than one. Assignment of a probability to the abnormal presence of a fuel is similar to the assignment of probability to an abnormal event, previously discussed, except the existence of accurate historical data is less likely.

c. Probability of Initiation

The preferred method of assignment of the probability of initiation is by use of the probit technique. This technique utilizes test data which is subjected to a regression analysis from which a probit plot is developed. This plot makes available the probability of initiation as a function of process energy.

A second technique for assignment of probability of initiation is by use of the calculated safety margin as shown in Table III-1. The method of calculating probability of initiation from margin of safety data is analogous to determining reliability for stress-strain problems as described in published reliability texts, such as "Lloyd and Lipow"[21].

In this program, each hazard identified was evaluated against a criteria of 10^{-6} probability of occurrence. A potential hazard for which the probability of occurrence is less than 10^{-6} is considered acceptable, and one for which it is greater than 10^{-6} is considered unacceptable. This criterion is based on the average hourly death rate for each worker in the United States (1.6×10^{-6}) as shown in the 1973 Accident Facts publication of the National Safety Council. Use of this criterion assures that the hazard to employees who work with the systems under consideration is not greater than that applicable to the average worker in the United States.

4. Hazard Analysis Summary Tables

The sequence of events that can potentially cause a problem in the pollution abatement system or any system follows a logical pattern. For the defined event to occur, several conditions must be met; (1) a combustible material must be present, (2) initiation stimulus must be present and (3) the combustible material will produce a response to the stimulus. The potential hazards identified in this analysis have been summarized in tables and are mentioned in the discussion of each equipment analyzed, which follows. The location of the data on the tables are outlined in Figure III-1.

Potential hazardous events were defined by logic modeling, therefore, the summarized events are indexed with logic model reference numbers. The numbers correspond to the logic model as shown in the example tree, Figure III-2.

B. CARBON ADSORPTION OF TNT PINK WATER

At all facilities which use TNT, TNT may be spilled and washed down with water, or removed from material in process during washing operations. This TNT contaminated water has been disposed of by dumping into local streams. In the carbon adsorption system, waste water is subjected to a t -step treatment. It is first filtered in a diatomaceous earth filter to remove suspended solids and then filtered through carbon columns to remove dissolved TNT.

The carbon adsorption system analyzed was based on the existing plant at Iowa Army Ammunition Plant (IAAP), but at the request of Picatinny Arsenal, did not include the regeneration process. The system analyzed consists of carbon adsorption columns, diatomite filter, circulating pump, settling tank, sump pump, sump and floor drain system (as partially depicted in Figure III-3).

A similar system at Joliet Army Ammunition Plant (JAAP) was also viewed for general information. The primary difference between the two facilities is the method of removing spent carbon and spent diatomaceous earth. JAAP pumps out the spent material with water and/or air into trucks for subsequent disposal, while IAAP manually shovels out the spent material into aluminum buckets.

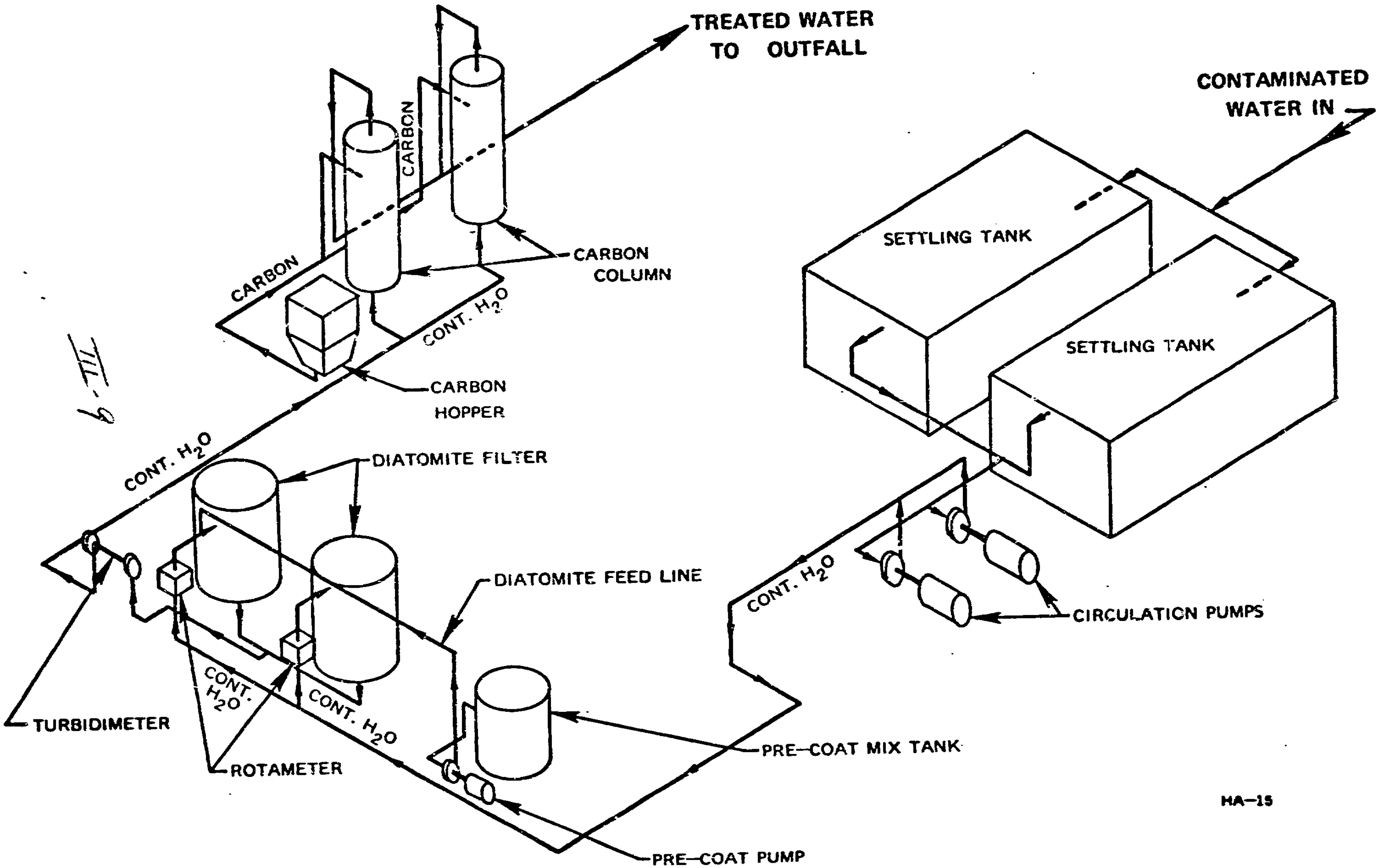

FIGURE III-3

Schematic Flow Diagram - Carbon Adsorption Waste Water Treatment Plant
40 GPM Plant (IAAP)

A single fuel source was considered for the undesired event - "fire or explosion results in personnel death or injury, or equipment damage." It was a layer of sufficiently dried TNT or its accompanying nitrobodies in a process unit. In its normal state in this system, TNT is highly dilute and results in no hazard. However, a more concentrated form, or a dried out layer can create a hazard. Five initiation modes were considered for the sufficiently dried layer. They were impact, friction, thermal, ESD, and electrical power discharge. Impact initiation threshold ranged from 31.6 ft-lb/in^2 for dry TNT to more than 72 ft-lb/in^2 for settled TNT (25-30% H_2O).[12,13] Frictional threshold initiation for dry TNT was at 190 kpsi at 2 ft/sec[12,13] velocity and for settled (wet) TNT was more than 77.5 kpsi at 8 ft/sec velocity.[12,13] At 2 ft/sec the settled TNT should be more than 190 kpsi[12,13] since the presence of water should increase the threshold level. For thermal initiation, data existed only for dry TNT. Its autoignition temperature was 230°C[12,13]. Wet TNT would have an auto-ignition temperature in excess of this value. For electrical ignition, TNT can be ignited by 0.075J[12,13], while water wet TNT requires 1.26J[12,13].

Preliminary testing of spent diatomaceous earth samples received from JAAP indicate that the material is insensitive to initiation when wet (~50% H_2O). The wet sample did not ignite and propagate a reaction from a J-2 cap donor. The dry spent diatomaceous earth (~ 7-8% TNT) is sensitive to initiation and may result in localized initiations. This is due primarily to the lumps of TNT it contains, which react in the same manner as pure TNT. A dried sample of the spent carbon received from JAAP was much less sensitive, probably because of the lower amount of TNT present, ~2.5% by weight. The as received, water-wet samples were insensitive to initiation by either impact or friction. Test results are shown below:

Sample	Threshold Initiation Level (20 Tests) Impact* ft-lb/in^2	Friction * psi at 8 fps	ESD joules
As Received:			
Spent Carbon (24% TV)	>62	>115,300	-
Spent Diatomaceous Earth (58% TV)	>62	>114,500	-
Dry:			
Spent Carbon	>62	103,000 @ 2 fps	0.50
Spent Diatomaceous Earth	3.7	103,000	0.075

*All impact and sliding friction utilized steel on steel components.

1. Carbon Adsorption Columns

Two identical carbon columns are each packed with activated carbon which adsorbs dissolved TNT from the water in the final process steps. Water from the filter enters the bottom of the bed and flows through the bed. The effluent from the first column flows to the bottom of the second column where the adsorption process is repeated and the water discharged to the sewer. Either column can receive flow from the filters, thus ensuring that the last column will have the freshest carbon. The columns are typically serviced when they do not produce water with less than 5 ppm TNT.

Analysis of the logic model has identified 20 minimum sequences of event which could cause the undesired event. Ten each came from two different independent sequences (probabilities of 10^{-6} and 10^{-11}, respectively) by which a sufficiently dry TNT or nitrobody layer could be produced. Two of the 20 cut-sets had probabilities equal to or greater than 10^{-6}. These were (1) the impact of carbon onto a combustible layer when filling or emptying the vessel, and (2) welding operation, assuming the maintenance man does not check and remove the combustible layer. A summary of the various ignition modes with their safety margins and probabilities and the maximum probability for the existence of sufficiently dry combustible layer is shown in Table III-II.

A check of the vessel prior to filling or emptying or a welding operation would decrease the probability of the undesired events to about 10^{-11}, provided that any layer would be subsequently removed. This would then be an acceptable hazard.

2. Diatomite Filter

The cylindrically-shaped filter has dished ends and is mounted vertically on legs. Its removable top is supported by a swivel arrangement to allow the lid to be raised and swung to the side when servicing Circular stainless steel cartridges mounted at the top of a vertical pipe support the filtering media. Each cartridge consists of an upper perforated plate fastened to a lower solid dish filled with baffles. A polypropylene bag surrounds each cartridge and is used to form a base for the diatomaceous earth filtering media. When the filter is serviced, the plates and supporting pipe are lifted from the filter vessel by a crane.

During operation, waste water and diatomaceous earth enter the filters, and flow over the cartridges. Water flows through the earth layer and leaves through holes in the supporting pipe at the center of the filter. This effluent water normally is free of suspended particles and contains only dissolved TNT. Under normal operations, the filter becomes clogged such that periodic cleaning is required.

Analysis of the logic model showed 22 sequences of independent events (minimum cut-sets) which could generate the undesired event. Eleven came from each of two different independent sequences (probabilities of 10^{-3} and 10^{-8}, respectively) by which a sufficiently dry combustible layer could be produced. Four had probabilities equal to or greater than 10^{-6}. They were (1) impact initiation from diatomaceous earth when sufficiently dry layer is present during filling or emptying the filter, (2) frictional initiation during maintenance when metal is rubbed over a sufficiently dry combustible layer,

(3) frictional initiation from movement of diatomaceous earth when a combustible layer is sufficiently dry, and (4) thermal initiation during a welding operation when combustible layer is sufficiently dry. This latter operation assumes that the maintenance man does not check for and subsequently remove the dried combustible. A summary of the various ignition modes with their safety margins and probabilities, and the maximum calculated probability for the existence of sufficiently dry combustible layer is shown in Table III-III.

A careful check for dry combustible and its removal (if any exists) before commencing either of the four hazardous operation mentioned in the preceding paragraphs will lower the event probability to less than 10^{-8}, decreasing the probability of any of the events by 10^{-5}. The spent earth should not be allowed to become completely dry, since this material is more sensitive in some respects (e.g., impact) than TNT.

3. Circulating Pump

The circulating pump moves the contaminated water from the settling tanks to the diatomite filters.

Analysis of the logic model has identified 22 sequences of events (minimum cut-sets), which could create the undesired event. Eleven came from each of two different independent sequences (probabilities of 10^{-4} and 10^{-9}, respectively) by which a sufficiently dry combustible layer could be produced. Only one had a probability equal to or greater than 10^{-6}. It was welding, assuming such maintenance is needed, when a sufficiently dry combustible layer is present. (The further assumption is made that the maintenance man does not check and remove such a combustible layer before making the repair.) A summary of the different initiation modes with their safety margins and probabilities is shown in Table III-IV along with the maximum probability calculated for the existence of a sufficiently dry combustible layer.

A check of the vessel prior to the welding operation would decrease the probability of the event to about 10^{-9}, assuming that any hazardous layer would be removed. This would then be an acceptable hazard.

4. Settling Tank

Two large settling tanks hold the contaminated liquid that comes from the sump pumps in order to separate the solids from the water.

Sixteen minimum cut-sets which could create the undesired event were identified by analysis of the logic model. Two different independent sequences (with probabilities of 10^{-5} and 10^{-10}, respectively) were shown in the model by which a sufficiently dry combustible layer could be produced; each generated eight of the 16 cut-sets. Only one had a probability of 10^{-6} or more. It again involved a welding operation when a sufficiently dry combustible layer is present. The assumption was again made that the maintenance man did not check for and remove the combustible layer.

Different initiation modes with their safety margins and probabilities are summarized with the calculated maximum probability for the existence of a sufficiently dry combustible layer in Table III-V.

A check of the tank and subsequently removal of the combustible layer (when present) would be required to lower the welding hazard probability to 10^{-10}.

5. Sump Pump

The sump pump propels contaminated water from the sump to the settling tank. The overall analysis is the same as the circulating pump previously mentioned. A summary table for initiation modes and existence of a combustible layer in this unit is shown in Table III-VI.

6. Sump Tank

The sump tank collects waste water from the floor drains. It is cleaned on a weekly basis. Maintenance personnel equipped with explosion proof tools enter the sump and shovel the TNT onto waiting trucks after the sumps have been pumped to their lowest point.

Sixteen minimum cut-sets were identified by computer simulation resulting from two sources of sufficiently dry combustible layers (probabilities of 10^{-5} and 10^{-10}, respectively). None had a probability of the undesired event greater than 10^{-8}. A probability of 10^{-5} (accidental) was assigned to the existence of a sufficiently dried combustible layer since extreme care is reported to be presently used during normal cleanup operations, and the same care would be expected when welding. A summarizing table is presented for initiation modes and existence of a flammable layer in Table III-VII.

7. Floor Drains (Trench)

The floor drains collect waste water and channel it to the sump.

Eighteen minimum cut-sets that could cause the undesired event were identified by analysis of the logic model. This results from two independent sources of obtaining a sufficiently dry combustible layer (probabilities of 10^{-5} and 10^{-10}, respectively). As with the sump tank, none had probabilities for the undesired event of more than 10^{-8} since an accidental probability of 10^{-5} was assigned to the existence of a sufficiently dried TNT layer due to the expected care to be taken during welding operations. Table III-VIII provides a summary of initiation modes and probabilities of existence of a combustible layer.

C. MOLECULAR SIEVE SYSTEM

The molecular sieve process analyzed in this study was the proposed system to be installed for treatment of tail-gas from the 55 ton per day nitric acid plant at Holston Army Ammunition Plant, described in a letter from Mr. W. C. Miller of Union Carbide to Mr. Alfred Tatyrek of Picatinny Arsenal[4]. Nitric acid plant tail-gas is the exhaust gas which emerges from the absorption tower (or scrubber) at the end of the nitric acid manufacturing process. This is the point at which the tail-gas is received by the molecular sieve process, shown in schematic form in Figure III-4.

In the molecular sieve system considered here, the tail-gas is first passed through a feed chiller, which cools the gas, condensing vapors, and then through a mist eliminator, where condensate is removed from the stream. The gas stream then goes to the molecular sieve, where nitrogen oxides are adsorbed by the adsorbent/catalyst before the gas is vented to the atmosphere.

Two identical catalyst/adsorbent vessels are provided so that one can be used in the adsorbing cycle while the other is being regenerated. Part of the exhaust gas from the adsorbing unit is fed to the regeneration system where it (the gas) goes through a compressor, a steam heater, an electric heater, the vessel being regenerated, a recycle gas cooler and a knock-out drum before being fed back into the absorption tower. During this cycle, the adsorbent/catalyst is cleaned so that it can be used again in the adsorbing cycle. Just before the regenerated adsorbent/catalyst vessel is placed back on stream, it is cooled by changing the regenerating gas stream flow from the steam and electric heaters to a cooler and chiller, so the vessel is at the proper temperature when it is returned to the adsorbing cycle.

The process units analyzed in a generalized logic model of this sytem are the feed chiller, the mist eliminator, the adsorbent/catalyst vessel, the regeneration compressor, the regeneration cooler and gas chiller, the regeneration gas steam heater, the regeneration gas electric heater and the recycle gas cooler.

The unavailability of flammable material makes it difficult to find significant hazards in this operation. A major upset would be required to produce a combustible mixture. It would require both larger quantities of oxidizer (more NO_x, HNO_3, O_2, NH_4NO_3, or NH_3) and a fuel source, such as a bearing leaking oil, or oil left inside the unit after maintenance. NH_4NO_3 and NH_3 are normally not present in the tail-gas but do exist in the HNO_3 process.

For "off-gas" mixtures of nitric acid tail-gas, that contain an oxidizer (normally very little) and a fuel from an external source (normally none), impingement, thermal, ESD, and electric power discharge modes were examinated for the "off-gas" cloud, while impact, friction, thermal, ESD, and electrical power discharge modes were investigated for "off-gas" deposits.

DSC work with a stoichiometric mixture of nitric acid and oil in water [60.6% HNO_3/37.2% H_2O/2.2% oil] identified an exothermic isotherm at 265°C[14]. This temperature is assumed to be the autoignition temperature of the mixture.

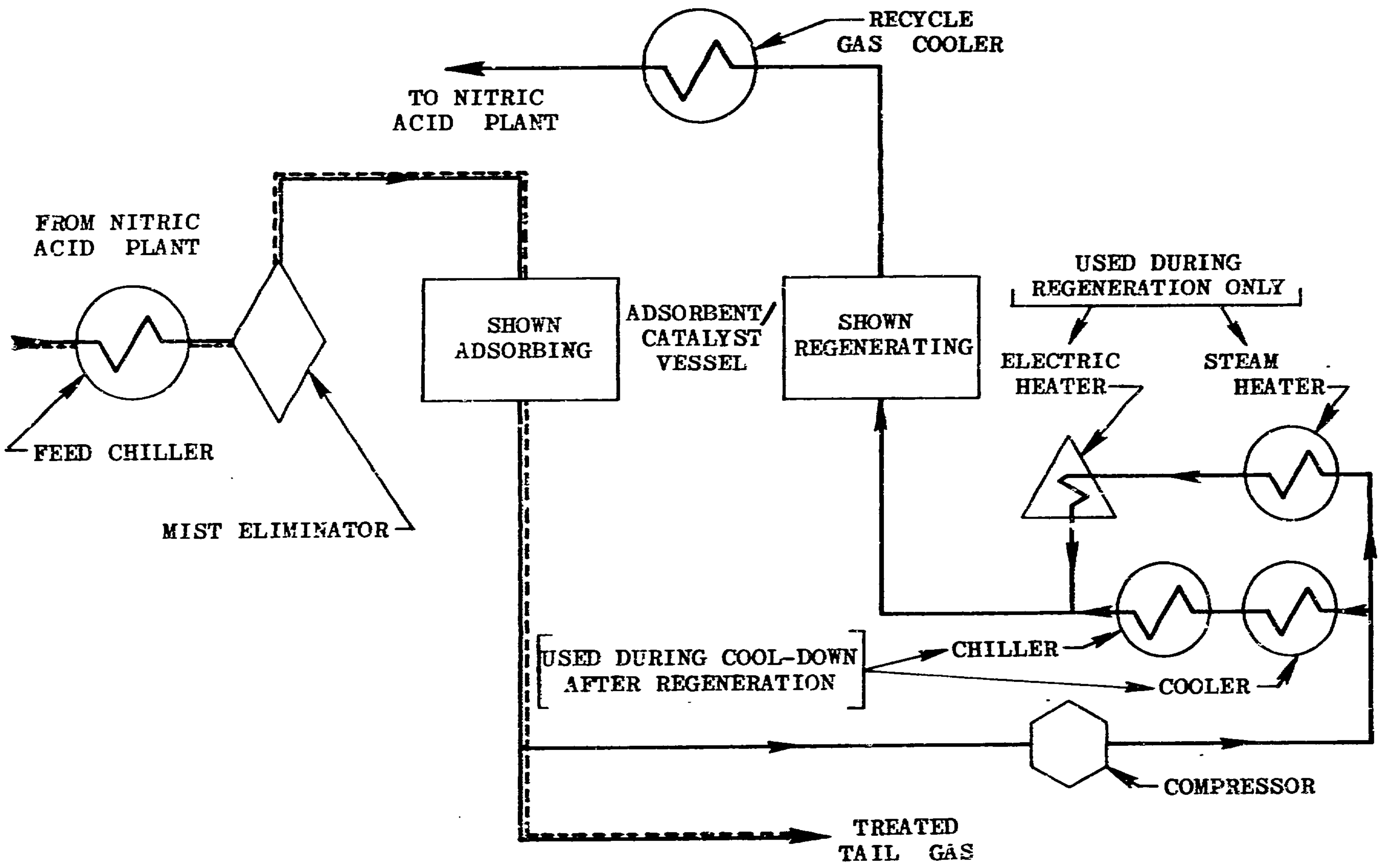

FIGURE III-4

Molecular Sieve System

Electrical discharge threshold initiation levels were reported for an HNO_3/oil/water (60.6/2.2/37.2) mixture as 0.075J[14]. This was the same as for a mixture of NH_4NO_3/HNO_3/oil/water (43.5/33.5/2.5/20.5). When NH_4NO_3/oil (94.5/5.5) mixture was used, 0.50J[14] was reported as the threshold level.

No in-process materials for the nitric acid plant were known to be ignitable by impingement.

The threshold impact initiation levels were more than 61.5 ft lb/in^2 for an NH_4NO_3/oil mixture[14], and more than 179K ft lb/sec[14] for either HNO_3/H_2O/oil mixture or $HNO_3/H_2O/NH_4NO_3$/oil mixture. The different dimensional units are due to the fact that the NH_4NO_3/oil mixture can exist as a solid; whereas, the other two are normally liquid.

The frictional threshold initiation levels are all at a velocity of 8 ft/sec instead of at the in-process velocity of 2 ft/sec. This gives a conservative estimate since threshold level is inversely related to velocity. These values at 8 ft/sec ranged from greater than 54.4 kpsi for HNO_3/NH_4NO_3/oil/H_2O mixture[14] to greater than 120 kpsi for NH_4NO_3/oil mixture[14].

1. Feed Chiller

The feed chiller normally cools the tail-gas from the absorption tower from 38°C (100°F) to about 10°C (50°F). This condenses most of the water and also the nitric acid formed by the reaction between water and nitrogen dioxide. The tail-gas is usually noncombustible; typically containing 96 percent by weight of inert nitrogen, some oxidizers and no fuel.

A probability of 10^{-10} was calculated for the existence of either a flammable gas mixture or a combustible "off-gas" deposit since either situation would require at least two simultaneous accidental events, such as an accident that oil was present, and at least one other simultaneous accidental failure which caused sufficient oxidizer to be present. Analysis of the logic model showed there are two ways a deposit could exist and four ways by which a flammable cloud could exist. The computer simulation of the generalized logic model showed 50 different minimum sequences of events (minimum cut sets) which could cause the undesired event. Eight involved impingement for which no in-process material was identified that could produce a hazard. Consequently, only 42 different sequences were applicable to this system. Of these, none was equal to or above the 10^{-6} incident probability used as a guideline for assessing a hazard. This, as previously stated, was due to the low probability of having flammable material present. A summary of the potential initiation modes is shown in Table III-IX with their safety margins and probabilities and with the maximum calculated probability for the existence of sufficient flammable materials.

2. Mist Eliminator

The mist eliminator removes entrained water and nitric acid from the tail-gas by passing the incoming stream through condensed liquid previously accumulated in the eliminator. The entrained liquid that is not picked up in the accumulator is "knocked-out" of the gas by a fiberous (loosely woven) gas deflector at the top of the eliminator.

As with the feed chiller, a major upset would be required to produce a combustible mixture. A probability of 10^{-10} was the maximum calculated during analysis of the logic model for existence of either a flammable gas mixture (two ways identified) or a combustible "off-gas" deposit (four ways identified) since either situation could result only from a double simultaneous failure.

Computer simulation of the generalized logic model identified 50 different minimum sequences of events (minimum cut-sets) which could cause the undesired event. Eight involved impingement, for which no in-process material was identified that could produce a hazard. Of the remaining 42 different sequences, none has a probability equal to or greater than 10^{-6}. A summary of the potential initiation modes is shown in Table III-X with safety margins and probabilities of the modes and with the maximum probability calculated for the existence of sufficient flammable material to support combustion.

3. Adsorbent/Catalyst Vessel

This unit is the principal unit in molecular sieve operation. Two such units exist such that one can be adsorbing when the other is being regenerated. In the adsorption operation, water, nitric oxide, and most of the nitrogen dioxide are selectively adsorbed onto the adsorbent/catalyst. In the regeneration operation, water and nitrogen dioxide are released from the adsorbent/catalyst. Regeneration is accomplished by heating the stream to the adsorbent/catalyst, and then (in order to make subsequent adsorption operation more efficient) the regeneration vessel is cooled before putting it back into the adsorption cycle.

a. During Adsoprtion - The adsorption process is exothermic, in which the incoming stream is typically heated from 13°C (55°F) to 35°C (95°F). The process streams are normally not combustible, containing only oxidizers and inert nitrogen (about 96%). A major upset would be required to produce a combustible mixture. Thus a probability of 10^{-7} was calculated for the existence of a combustible layer (one way identified), since a double simultaneous accidental occurrence would be required for its existence (the oxidizer could selectively build up on the catalyst as the fuel and contaminating oil possibly could also). For a combustible vapor, the maximum probability was calculated to be 10^{-9} (five ways identified) since vapors should be of a more inert nature than an accumulated layer.

The undesired event could be caused by 67 different minimum sequences of events (minimum cut-sets) identified by computer simulation of the generalized fault tree. Since a combustible for impingement has not been identified for the nitric acid process, only 52 different sequences are applicable. Of these, none has a probability greater than or equal to 10^{-6}, again due to the low probability of sufficient combustible material existing. A summary of the potential initiation modes is shown in Table III-XI with safety margins and probabilities of the modes and with the maximum probability calculated for the existence of sufficient flammable materials.

b. Regeneration Heating - The desorption of the nitrogen oxides and water from the adsorbent/catalyst is an endothermic process. Heat is supplied by a portion of the exit from the other adsorbent/catalyst vessel in which adsorption is occurring. Typically this stream is heated from 35°C (95°F) to 288°C (550°F). The gas stream is normally noncombustible, typically containing 97 percent inert nitrogen, about 3 percent oxygen and trace of nitrogen dioxide.

As with the other process unit discussed, a major upset would be required to produce a combustible mixture. The normal quantity of oxidizer is small, and normally no fuel is present. A maximum probability of 10^{-9} was calculated for the existence of either a flammable gas mixture (four ways identified) or a combustible "off-gas" deposit (one way identified), since either situation would require double simultaneous accidental occurrences.

Computer simulation of the generalized fault tree showed 56 different minimum sequences of events (minimum cut-sets) which could cause the undesired event. Twelve involved impingement for which no in-process material was identified that could produce an impingement hazard. Consequently, only 44 different sequences were applicable for this system. None has a probability larger than or equal to 10^{-6}. A summary of the potential initiation modes is shown in Table III-XI with safety margins and probabilities of the modes and with the maximum probability of the existence of sufficient flammable material.

c. Regeneration Cooling - Regeneration cooling of the adsorbent/catalyst vessel is conducted after regeneration heating and prior to adsorption in the adsorbent/catalyst vessel. The operation is performed to prepare the vessel for the exothermic adsorption process.

As with the other process units, a major upset would be required to produce a combustible mixture. The normal quantity of oxidizer is small and normally no fuel is present. A maximum probability of 10^{-9} was calculated for the existence of either a flammable gas mixture (5 ways identified) or combustible "off-gas" deposit (2 ways identified) based on the same rationale as that presented in the "Regeneration Heating" section.

Computer simulation of the generalized fault tree showed 72 different minimum cut-sets which could cause the undesired event. Fifteen of them involved impingement, for which no in-process material was identified that could generate a hazard. Therefore, only 57 minimum cut-sets are applicable for this system, none of which has a probability equal to or above the 10^{-6} guideline. This is due to the low probability of having combustible material present. A summary of the potential initiation modes is shown in Tables III-XI with their safety margins and probability and with the maximum probability of the existence of sufficient flammable material.

d. When not operating - no logic model was drawn for this system. The structure of the model would be similar to the vessel during the adsorption operation. The probability of existence of flammable material would be less, and the probability of an initiation stimulus during a maintenance operation would be 1.0. Since the probability of a flammable material being present is less than 10^{-7}, no hazard which needs correction is identified, based on the 10^{-6} guideline.

4. Regeneration Compressor

The regeneration compressor provides sufficient pressure to the feed to the regeneration adsorbent/catalyst vessel such as to be able to add this stream to the knockout drum prior to its addition to the absorption tower.

The regeneration compressor performs the same function during regeneration heating as during regeneration. The only difference is that during regeneration cooling it receives gas from near the end of the adsorption operation, whereas during regeneration heating it receives gas from the beginning of the adsorption operation. Near the end of the adsorption operation the adsorbent/catalyst would not have as good adsorption characteristics since most of its adsorption sites would be filled and more oxidizer would be in the gas stream. However, under normal circumstances no fuel and little oxidizer (about 3 percent) are present.

During its operation, the compressor typically pressurizes the stream from 77.6 psig to 110 psig while heating it from 35°C (95°F) to 79°C (175°F).

In both the regeneration heating and the regeneration cooling operations, a major upset would be required to generate a combustible mixture as previously discussed in other process units. Consequently, a maximum probability of 10^{-10} was placed on the existence of either a flammable gas mixture (5 ways identified) or a combustible "off-gas" deposit (2 ways identified) since either situation would require two simultaneous accidental occurrences.

Analysis of the generalized fault tree showed 77 minimum cutsets which could cause the undesired event during the regenerating heating cycle. Ten of these involved impingement for which no in-process material was identified that could produce a hazard. Consequently, only 62 different sequences are applicable to this system. None had probabilities greater than or equal to the 10^{-6} used in assessing a hazard. A summary of the potential initiation modes is presented in Table III-XII with safety margins and probabilities of the modes and with the maximum probability for the existence of sufficient flammable material.

During the regeneration cooling cycle, computer simulation of the generalized fault tree showed 70 minimum cut-sets which could cause the undesired event. The difference between the heating and cooling cycles is in the ESD initiation mode. ESD potential from airveying the "off-gas" and the adsorbent/catalyst were considered separately in the heating cycle but combined for the cooling cycle. In the regeneration cooling cyc 60 different minimum cut-sets were considered applicable (impingement wa eliminated from consideration as a source) to the plant. None present a probability of occurrence greater than or equal to 10^{-6}, due to low probability of having combustible material present. A summary of potential initiation modes is given in Table III-XII with safety margins and probabilities of the modes and with the maximum probability of existence of sufficient flammable material to cause an incident.

As with the adsorbent/catalyst vessels, no logic model was drawn for the compressor when not operating. The structure would be similar to the compressor during either regeneration cooling or regeneration heating. The existence of flammable material would have a lower probability although the probability of an initiation stimulus during a maintenance operation would be 1.0. Since the probability of a flammable material being present is less than 10^{-10}, no hazard which requires corrective action was identified.

5. Regeneration Gas Steam Heater

The regeneration gas steam heater is connected directly to the outlet of the compressor. Steam is used to heat the compressed gas for the regeneration heating operation. The gas is typically heated from 79°C (175°F) to about 182°C (360°F).

As in the other process units, a major upset would be required to generate combustible material. Consequently, a maximum probability of 10^{-10} was assigned to its existence (2 ways identified for a layer and 4 for a cloud) as for the other process units.

Analysis of the generalized fault tree showed 56 different minimum sequences of events which could cause the undesired event. Eight involved impingement, for which no in-process material was identified that could produce a hazard. Consequently, only 48 are applicable to this system, and none had a probability equal to or above the 10^{-6} incident probability criteria. A summary of the potential initiation modes is shown in Table III-XIII with safety margins and probabilities of the modes and with the maximum probability for the existence of sufficient flammable material to support combustion.

6. Regeneration Gas Electric Heater

The regeneration gas, as it leaves the steam heater, is further heated in the electric heater to 288°C (550°F).

A major upset would be required to generate combustible material. Thus a maximum probability of 10^{-10} was assigned to its existence (2 ways identified for a layer and 4 ways for a cloud).

Sixty eight minimum cut-sets were found in the analysis of the generalized logic model which could cause the undesired event. Eight involved impingement which is not applicable to this plant. Consequently, 60 cut-sets apply to this system. None, however, had a probability of occurrence greater than or equal to 10^{-6}. A summary of the potential initiation modes is given in Table III-XIV with safety margins and probabilities of the modes and with the maximum probability for the existence of flammable material.

7. Regeneration Cooler and Gas Chiller

The regeneration cooler and gas chiller are connected in series to the compressor discharge and are activated during regeneration cooling. They cool the discharge from 79°C (175°F) to 66°C (150°F).

As with the other process units, a major process upset would be required to generate a flammable material; consequently, a maximum probability of 10^{-10} was calculated for its existence, (1 way identified for a layer and 5 ways for a cloud).

Sixty five minimum cut-sets were shown in the computer simulation of the generalized logic model, ten of which pertain to an impingement initiation. Since no in-process material was identified that could produce an impingement initiation hazard, only 55 apply to the nitric acid facility. None, however, had probabilities for the undesired event equal to or greater than 10^{-6}. A summary of the potential initiation modes is shown in Tables III-XV and XVI with safety margins and probabilities of the modes and with the maximum probability for the existence of sufficient flammable material.

8. Recycle Gas Cooler

The recycle gas cooler cools the gas from the adsorbent/catalyst vessel during regeneration before it combines with the nitric acid stream entering the knockout drum. During regeneration heating, this stream is cooled to 260°C (500°F) and it is cooled to 21°C (70°F) during regeneration cooling.

As with other units in this process, simultaneous major upsets would be required to permit flammable material to exist. A probability of 10^{-10} is calculated for a flammable cloud (1 way identified) and 10^{-12} for a layer of "off-gas" (5 ways identified).

Analysis of the generalized logic model showed 49 minimum cut-sets which could cause the undesired event. Thirty nine of these were applicable to the nitric acid system since ten pertained to impingement, for which no in-process material was known to be ignitible. None had probabilities equal to or greater than 10^{-6} for the undesired event. A summary of the potential initiation modes is shown in Table III-XVII with safety margins and probabilities of existence of the modes and of the maximum probability for the existence of sufficient flammable material to support combustion.

D. FLUIDIZED BED INCINERATION OF EXPLOSIVES AND PROPELLANTS

The basis for the fluidized bed system was provided by specifications[15] for changing the vertical incinerator at Picatinny Arsenal to a fluidized bed. This system was based on research at Esso Research and Engineering Company and assumed that the proepllant/explosive feed slurry is available at the bed, so preparation of the slurry is not included in this analysis. The incinerator is depicted in Figure III-5.

Several process units were considered in this study. The air intake filter mufflers, air blower (compressor), and discharge muffler normally deliver particle-free air to the burner and the bed. The burner serves as the ignition chamber for fuel oil, which subsequently burns in the pre-heater before entering the plenum for further combustion. Hot burning gases flow into the bed chamber through a grid which separates the bed from the plenum. The hot gases fluidize the bed material (alumina base), slurried propellant or explosive, and auxiliary fuel oil, if necessary. The combustion products are carried, as a gas particulate stream, into a cyclone separator, from which normally particle-free gas flows into the stack.

The process is carefully controlled by a "Flame Guard" in the pre-heater, and an operational control center. The operational control center contains interlocks for sequential and alarm conditions and blocks certain circuits until proper operating conditions have been met.

Four fuel sources were considered for the undesired event of "fire or explosion results in personnel death or injury or equipment damage." Natural gas exists as a pilot gas at the burner. Fuel oil provides fuel for the burner as well as auxiliary fuel to the bed. Propellant or explosive enters in the slurry feed to the bed or possibly as a polluting dust from the air intake filter muffler. Unburned propellant or explosive, or a layer of unburned combustible byproducts of propellant or explosive material was the third source. The fourth fuel was a cloud of unburned propellant or explosive material or a cloud of combustible byproducts of propellant or explosive.

Three propellant and explosive materials are presented as typical materials. They are M1 propellant[15], TNT[12,13], and N5 propellant[17]. The probabilities shown in the summarizing tables represent the worst situation; e.g., the lowest safety margin of the three materials was used in determining the probabilities of initiation. If one material caused a hazard and another did not, as defined by the 10^{-6} incident probability, it was so noted.

Two sets of initiation modes were defined for propellant or explosive materials, one for a dust cloud and the other for a dust layer. Impingement, thermal, ESD, and electrical power discharge modes were analyzed as potential initiation modes for the combustible.

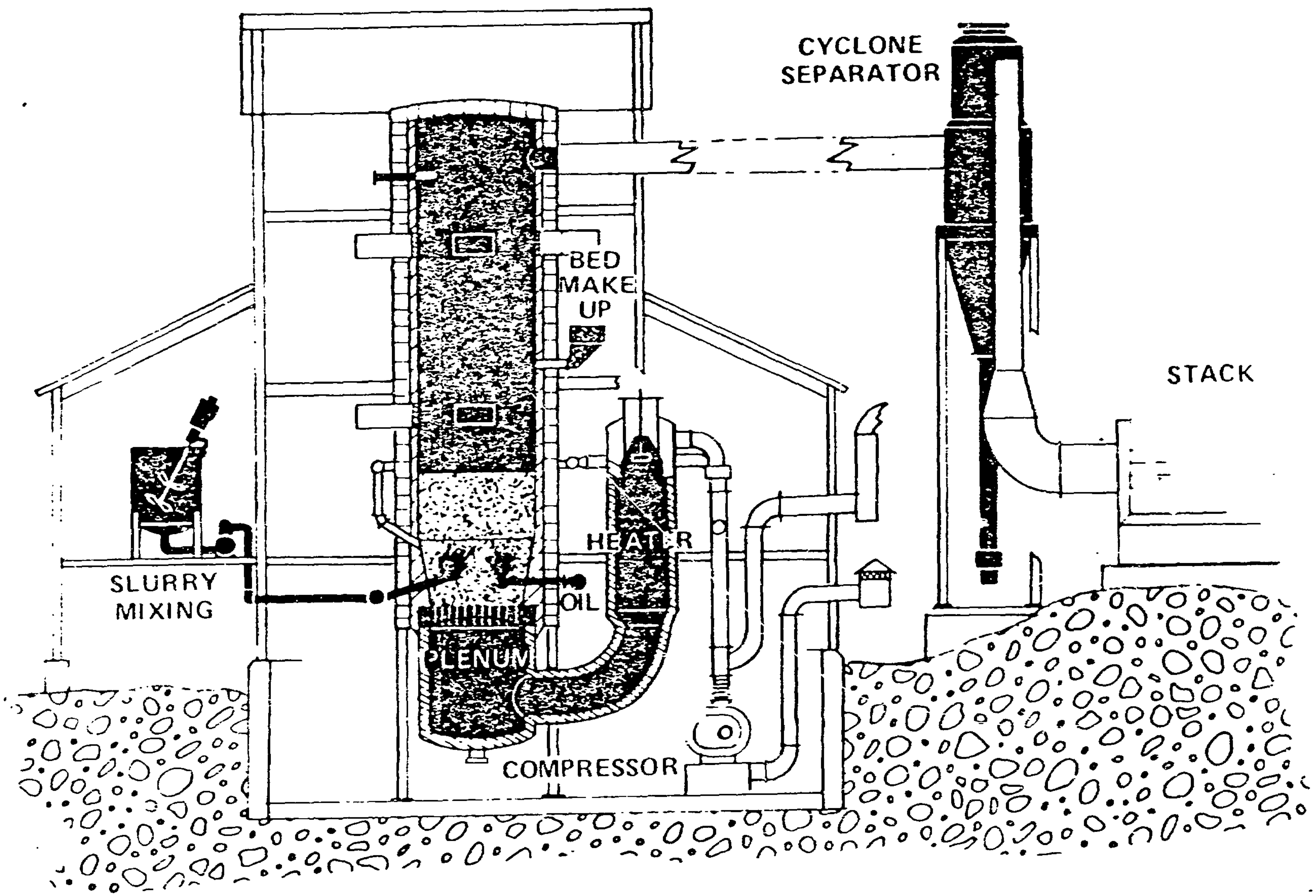

Figure III-5 Picatinny Arsenal Fluidized Bed Incinerator

For minimum impact energy, threshold initiation on stainless steel was used. Initiation levels ranged from 3.8 ft-lb/in^2 for M1 propellant[16] to 31.6 ft-lb/in^2 for TNT[12,13].

Frictional initiation material response values (TILs) at 2 ft/sec velocity were used. The values were 34 kpsi for N5 propellant[17], 190 kpsi for TNT[12,13] and 120 kpsi for M1 propellant.

Thermal initiation levels were constant for TNT and N5 propellant, at 230°C[12,13] and 150°C[17] respectively. The autoignition temperature of M1 propellant was strongly time dependent. After 24 hours at 120°C, M1 will reportedly ignite[16]. This was used as the autoignition temperature for a layer of M1 propellant. However, M1 will reportedly ignite at 150°C after only one hour; this was used as the autoignition temperature for a dust cloud.

Similar variation existed for electrical ignition, both from ESD and electrical power discharge. Both TNT and N5, in either cloud or layer, were reportedly ignited by 0.075J[12,13,17]. However, M1 required only 0.013J[16] to ignite as a layer but 0.024J[16] to ignite as a dust cloud.

The impingement initiation threshold levels for these materials varied from greater than 10,000 ft/min for a layer of M1 dust[16] to 38,000 ft/min for TNT[12,13].

For natural gas and fuel oil, thermal, ESD, and electrical power discharge initiation modes were evaluated. Natural gas has an ignition temperature of about 210°C[18] and a electrical ignition threshold of 0.002J[19]. Fuel oil is harder to ignite thermally, with an ignition temperature of 482°C[18], but is much easier to ignite electrically, requiring only 0.47 mj[19].

1. Air Intake Filter Muffler

All air supplied to the fluidized bed enters the process through the air intake filter muffler. At the time of the analysis, the specifications of the intake muffler were not known to Picatinny Arsenal. Consequently, the assumption was made that the filter material was of the fibrous cloth type, which is combustible and capable of generating an electrostatic charge.

Initiation of the filter material was considered very unlikely.

The presence of fuel oil and pilot gas in the air intake muffler were not considered, due to the barrier created to a path from the burner to the intake muffler by the air blower when the blower is not operating. When it is operating, air from the blower transports these fuels further away from the muffler.

Two other fuel sources whose presence was considered remote were analyzed in detail. The fuel sources were the previously discussed combustible (propellant or explosive material or byproducts) layer and cloud. Analysis identified 60 minimum sequences of events which might cause the undesired event of "fire or explosion results in equipment damage or personnel injury or death." Thirty-three applied to a combustible layer and 27 to a cloud. Three independent sequences were described in the logic model by which either a cloud or layer could develop in the intake filter. The maximum probabilities were 10^{-8} for the existence of a layer and 10^{-13} for a cloud. Since both probabilities are less than 10^{-6}, no unacceptable hazard was identified.

Summaries of the initiation modes for the intake filter are shown in Table III-XVIII. These describe safety margins and probabilities calculated for the initiation modes as well as the maximum calculated probability for existence of the fuels.

2. Air Blower

A constant displacement type blower supplies air for combustion, fluidization, and flue gas quality control. It is started manually. A time delay relay (TDR-1) on the manual start-stop switch controls a solenoid valve (SV-102) on the outlet of pressure controller PC-1 to allow butterfly valve BV-101 to remain open, venting the blower to atmosphere during starting, to prevent pressure buildup in the preheater.

At expiration of the planned delay time, relay TDR-1 operates, causing valve SV-102 to open, allowing pressure controller PC-1 to modulate valve BV-101 in order to maintain a pressure of about 6.2 psig in the air supply line.

All four sources identified as fuels for the undesired event in the fluidized bed system were considered for the air blower even though their probabilities are low. Analysis identified 129 minimum cut-sets for the undesired event. Thirty-six are from three independent sequences identified by the logic model for producing a combustible layer, 30 are from three sequences that generate fuel oil, and 28 are from four sequences that provide natural gas. The maximum probabilities calculated for the existence of sufficient fuel were 10^{-9} for a layer, 10^{-13} for a cloud, 10^{-12} for oil, and 10^{-12} for natural gas. Since all probabilities of the presence of fuel for the undesired event and thus for initiation were below the incident probability of 10^{-6}, no unacceptable hazard was found for the air blower.

Summaries of the initiation modes for the air blower are shown in Table III-XIX, describing the safety margins and probabilities calculated for these initiation modes as well as the maximum calculated probability for existence of fuels.

3. Discharge Muffler

The discharge muffler decreases the noise level of an auxiliary stream from the air blower to an acceptable level. This side stream also helps control the air supplied to the fluidized bed.

Since the discharge muffler is downstream of the air blower, a path exists for fuel oil or pilot gas to migrate to the discharge muffler when the air blower is not operating. Thus, fuel oil and pilot gas can be considered along with the combustible layer and cloud as potential fuel sources.

Ninety minimum cut-sets were identified by analysis of the logic model for the discharge muffler. Thirty resulted from layer initiation with the maximum probability for three different sequences for the existence of the layer being 10^{-9}. Twenty-four developed from cloud initiation with 10^{-13} being the maximum probability for three different sequences by which the cloud could exist. The maximum probability for the existence of flammable fuel oil or pilot gas was 10^{-16}. Five different sequences for existence of fuel oil resulted in 25 minimum cut-sets for the undesired event, while four different sequences for the existence of pilot gas resulted in 20 minimum cut-sets for the undesired event. Consequently, no unacceptable hazard was identified for the discharge muffler since all probabilities for sufficient fuel for the undesired event were below the 10^{-6} incident probability.

Initiation modes for the discharge muffler are summarized, with their safety margins and probabilities, in Table III-XX. The maximum calculated probability for the existence of fuel is also presented there.

4. Burner

The burner is the primary initiation chamber for fuel oil supplied to the grid.

Startup of the burner is critical to operation of the system. Blower air must be available at some minimum flow rate through the combustible air controller (FC-2) and the control valve (V-105). The start button (FB-1) is then pressed and held to activate the Flame Guard, the pilot gas solenoid valve control, and the electrical igniter for the pilot gas. (Details of the ignition system were not available so the analysis is general.)

At the command of the burner control (FC-2), the solenoid valve SV-203 opens to introduce oil to the proportioning control valve. An internal bypass (V-204) is set to a minimum ignition flow if high pressure atomizing air is available at the pressure switch (PS-6) and the temperature controller (TC-1) is set to an internal low temperature limit.

The Flame Guard takes over as soon as the Flame Guard Eye senses a proper oil flame at the burner, and the start push button may be released. If the flame is not recognized within a set time, SV-203 is de-energized, and the oil supply is shut off. SV-203 is also closed instantly if the Flame Guard Eye senses a blow-out or no flame and manual restart must then be initiated.

Four fuel sources were considered in the logic model. They were the previously discussed combustible layer, cloud, pilot gas, and fuel oil. Existence of the first two is unlikely, whereas the latter two are present during normal operations.

One hundred fifty-nine different sequences of events were identified by analysis of the logic model leading to the undesired event. Forty-two resulted from three independent sequences by which the combustible layer could be present. Three independent sequences by which the combustible cloud could exist in the burner resulted in 36 minimum cut-sets for the undesired event. The maximum probability for the existence of either a combustible layer or a combustible cloud was 10^{-13}. Thus, 78 minimum cut-sets for the undesired event for these combustible materials were identified as acceptable hazards. Five independent sequences by which sufficient fuel oil can exist and four for sufficient pilot gas produced respectively, 46 and 36 minimum cut-sets for the undesired event. The maximum probability for sufficient flammable fuel oil or pilot gas to exist in the burner is calculated as 10^{-4}. This would occur when a system failure in the pilot gas feed line transports sufficient pilot gas to the burner. (Insufficient detail on this phase of the system necessitates this assumption.) This gas might extinguish or partially extinguish the flame and subsequently reignite, causing a hazard. Design of the pilot gas line to limit pilot gas flow can prevent this problem, if it exists. A similar situation could exist for fuel oil. By neglecting these modes, no sequences of events were observed for the existence of fuel oil or pilot gas with a probability of more than 10^{-8}, due to the control system.

Three sources of initiation were identified for both fuel oil and pilot gas. Thermal sources were the only initiation modes that could cause an unacceptable hazard (probability greater than or equal to 10^{-6}) for the previously discussed 10^{-4} probability of fuel being present. They include normally occurring burner fire, normally occurring fire in the preheater, and residual heat from extinguished fire. Adequate design to limit pilot gas and fuel oil flows, as previously stated, would eliminate these hazards.

Summaries of the various initiation modes with their probabilities and safety margins are presented, with the maximum calculated probability of existence of sufficient fuels, in Table III-XXI.

5. Preheater

Fuel oil that is ignited in the burner is transported by the air stream into the preheater. This preheater is a large chamber into which the burner opens. The previously mentioned Flame Guard is actually located in the preheater.

Fuel sources considered were the same four as for the burner.

One hundred seventy-four minimum cut-sets which could produce the undesired event were identified by computer simulation of the logic model.

Forty-five and thirty-nine resulted from three sequences for generating the combustible layer and the combustible cloud, respectively. Both had a maximum probability for the existence of the cloud or layer of 10^{-13} and were thus considered acceptable hazards. Ten independent initiation modes were applicable to five sequences which might produce sufficient flammable fuel oil and to four sequences which might produce sufficient flammable pilot gas. Both had a probability of 10^{-8} that sufficient flammable material would be present. Thus, neither resulted in an unacceptable hazard, since probability of the undesired event was less than 10^{-6}.

Summaries of the initiation modes for the preheater are shown in Table III-XXII. These describe the safety margins and probabilities calculated for these initiation modes as well as the maximum calculated probability for existence of the fuels.

6. Plenum

The same four fuels were considered for the undesired event in the plenum as in the preheater.

Two hundred and five minimum cut sets that could produce the undesired event were identified by computer simulation of the logic model. Sixty-five resulted from a combustible layer, 60 from a combustible cloud, 48 from fuel oil, and 32 from pilot gas. None were unacceptable hazards due to the low probability of having sufficient material. Five sequences for a combustible layer and five for a combustible cloud had maximum probability of 10^{-8}. Six fuel oil sequences had a maximum probability of 10^{-16} as did the four pilot gas sequences.

The initiation modes for the plenum are summarized with their safety margins and probabilities in Table III-XXIII. Also included in these tables are the maximum probability for the existence of sufficient combustible materials.

7. Grid

The grid serves two principal purposes. It helps distribute the gas flow uniformly throughout the bottom of the bed, and also separates the fluidized bed from the plenum.

Analysis of the logic model showed 185 minimum cut-sets that could cause the undesired event. None, however, generated an unacceptable hazard due to the low probabilities calculated for sufficient fuel existing. Five sequences for creating a combustible layer caused 60 minimum cut-sets for producing the undesired event; however, the maximum probability for the existence of sufficient combustible was only 10^{-8}. The same situation existed for the flammable cloud except only 55 minimum cut-sets were identified which could cause the undesired event. Six minimum sequences for accumulating sufficient fuel oil were given in the logic model to develop 42 minimum cut-sets for the undesired event; the probability of sufficient fuel oil existing was only 10^{-16}. For natural gas, only four sequences were identified to accumulate a sufficient quantity in the grid. This generated 28 minimum cut-sets for the undesired event, although none resulted in an unacceptable hazard, due to the maximum probability of 10^{-20} for existence of sufficient flammable fuel oil.

A summary of the initiation modes with their safety margins and probabilities, and the maximum calculated probability for the existence of sufficient combustible materials is shown in Table III-XXIV.

8. Bed

Combustion of the slurried propellant or explosive is the primary operation performed in the fluidized bed. Other operations such as adding makeup bed material are also considered.

Most feeding operations are semi-automatic and have control interlocks. One example is the in-bed oil feeding operation. As the fluidized bed temperature is raised to the fuel oil autoignition temperature during startup, the oil low bed temperature control (TC-3) will indicate by glowing lights that the in-bed injection oil circuit may be activated. Activation before this point is prevented by an interlock in the flow control center (FC-3) and the safety and operational control panel (CP-1). However, the possibility of an erroneous (too high) reading from TC-3 could override the interlock. Consequently, careful check must be made by the operator before activating the in-bed injection oil circuit.

By activation of an acknowledgment button on the safety control panel (CP-1), one or more pairs of oil injection nozzles (SV-209 to SV-214) may be opened to a minimum flow at the command of a flow control in the in-bed oil flow control center. The number of oil injection nozzle pairs is completely at the discretion of the operator. They may be activated or deactivated through the in-bed oil flow control center. This will block the temperature controller (TC-4) output to in-bed oil flow control center (FC-3) in the event that the oil low bed temperature limit control (TC-3) falls below the minimum ignition temperature of the oil.

The flow, as set by (FC-3), is increased gradually to obtain a predetermined temperature, at which time a low temperature control (TC-5) will indicate to the slurry control center (FC-4) that the slurry valves can be opened or activated.

Before the slurry can be injected into the bed, the operational control center (CP-1) requires that the blower is started, the preheater burner is igniting the fuel oil, and the in-bed injection system activated. In addition, it assures that the oil pressure switch (PS-5) on the oil to control valves (V-206, V-207, V-208) is activated and a minimum fluid bed temperature of 1300°F to 1650°F is sensed by the slurry low temperature control (TC-5).

The slurry injection nozzles are all supplied by one control valve (PC-301) during normal operation but may be individually shut off and purged remotely by a remote nozzle purge selector switch center. When the minimum fluid temperature is reached, TC-5 plus PS-5 in the oil injection line and PS-1 in the purge water line allow the slurry injection valve (PV-301) to be operated.

During normal shutdown procedures, the slurry control center stop button (PB-3) is pressed, deactivating the slurry supply valves and activating the slurry nozzle flush cycle. The emergency back-flush should be followed shortly thereafter.

The primary function of control panel (CP-1) is to prevent any slurry from being injected into the fluid bed before proper ignition conditions are obtained, and to prevent slurry from remaining in the header lines after system shutdown due to an alarm condition.

Four situations constitute an alarm condition. They are (1) loss of main injection oil pressure, (2) lowering the fluid bed temperature below the predetermined combustion temperature of the slurry, (3) an excessively high temperature either above the bed or at the entrance to the cyclone separator, and (4) loss of fluidizing air pressure either by loss of electrical power for the blower, or malfunction of the butterfly valve feeding air through the preheater to the plenum chamber.

The in-bed oil flow center is under the control of the operational control center and can have its total oil shut off (and be deactivated) by (1) decreased fluidization (minimum under grid plenum pressure), (2) reduced cooling water pressure, or (3) minimum alarm temperature in the top of the incinerator tower (TI-7).

The same fuel sources were considered in the logic model for the bed that were considered for the grid.

Computer simulation of the logic model showed 202 minimum sequences of events which could generate the undesired event. However, due to the low probability of having sufficient flammable present, no unacceptable hazards were identified. Five independent ways by which a sufficient combustible layer could exist and five for the combustible cloud each had a maximum probability of 10^{-8}. Five sequences by which sufficient flammable fuel oil could exist had a maximum probability of 10^{-12}, while four for pilot gas had a 10^{-24} probability that sufficient flammable gas is present. Of the 202 minimum sequences previously mentioned, 70 resulted from a layer being initiated, 60 from a cloud being initiated, 40 from fuel oil being initiated, and 32 from pilot gas being initiated.

Summaries of the initiation modes for the bed are shown in Tables III-XXV. These describe the safety margins and probabilities calculated for these initiation modes as well as the maximum calculated probability for existence of the fuels.

9. Cyclone Separator

The cyclone separator removes particulate matter from the bed effluent gas by using centrifugal force to amplify the settling rate of the particles. It consists of a vertical cylinder with a conical bottom, a tangential inlet near the top and an outlet for dust at the bottom of the cone.

Two fuels were considered in the logic model. They were a combustible layer and a combustible cloud.

Computer simulation of the logic model identified 110 different sequences by which the undesired event could develop. Sixty resulted from five different sequences by which a combustible layer could exist. A maximum probability of 10^{-8} was calculated for the presence of a combustible layer. Ten different initiation modes resulted in 50 sequences by which the undesired event could be caused from five independent sequences for a combustible cloud. The maximum probability was also 10^{-8} for the existence of a combustible cloud.

Summaries of the initiation modes with safety margins and probabilities are shown in Table III-XXVI, along with the maximum probability for existence of sufficient fuel.

10. Stack

The stack is a large chimney into which the exhaust gases from the cyclone separator are transported.

The same two fuel sources, a combustible layer and a combustible cloud, considered in the cyclone separator are applicable to the stack.

Computer simulation of the logic model identified 110 independent sequences by which the undesired event could occur. However, due to the maximum calculated probability of 10^{-8} that a combustible layer or a combustible cloud could be present, no unacceptable hazards were identified. Five sequences by which the combustible layer could occur accounted for 60 of the 110 independent sequences for the undesired event, while five sequences for the combustible cloud accounted for the other 50.

Summaries of the initiation modes with their safety margins and probabilities are shown in Table III-XXVII, along with the maximum probabilities for the existence of fuel.

D. INCINERATION OF CONTAMINATED INERT WASTE

The basis for the analysis was the prototype contaminated waste incinerator described in a final report by Uniroyal, Inc.[5] and located at Joilet Army Ammunition Plant (JAAP). It consists of four basic process units: (1) a hopper, (2) a dual action ram charger, (3) a dual chamber furnace and (4) a stack. A sketch of the system appears on Figure III-6. Shredded cardboard and paper that previously contained explosive or propellant materials are visually inspected prior to addition to the hopper and subsequent combustion in the furnace.

Three fuel sources were considered for the undesired event - "fire or explosion results in equipment damage or personnel death or injury." The most plausible was propellant or explosive material. It could be present in sufficient quantity as a cloud or a layer if the operator did not check materials in process and remove undesired material. Three examples of possible contaminants were selected as being typical: M1, TNT, and N5. Other potential fuel sources were natural gas and fuel oil. Natural gas is used in the existing furnace although fuel oil might be used in some future design or possibly in a modification to the existing furnace.

As in the fluidized bed, two sets of initiation modes were defined for propellant or explosive materials, one for a dust cloud and another for a dust layer. Impingement, thermal, ESD, and electrical power discharge modes were evaluated as potential initiation modes for a cloud of combustible. Impact, friction, thermal, ESD, and electrical power discharge modes applied to a combustible layer.

For minimum impact energy, threshold initiation on stainless steel was used. Initiation levels ranged from 3.8 ft lb/in^2 for M1[16] to 31.6 ft lb/in^2 for TNT[12,13].

Frictional initiation material response values (TILs) at 2 ft/sec velocity were used. The values were 34 kpsi for N5 propellant[17], 190 kpsi for TNT[12,13] and 120 kpsi for M1 propellant.

Thermal initiation levels were constant for TNT and N5, 230°C[12,13] and 150°C[17] respectively. The M1 autoignition temperature was time dependent. After 24 hours at 120°C, M1 will reportedly ignite[16]. This was used as the ignition temperature for a layer of M1. However, M1 will reportedly ignite[16] at 150°C after only one hour; this was selected as the autoignition temperature for the dust cloud.

Similar variation existed for electrical ignition, both from ESD and electrical power discharge. Both TNT and N5 in either a cloud or a layer were reportedly ignited by 0.075J. However, M1 required only 0.013J[16] to ignite as a layer but 0.024J[16] to ignite as a dust cloud.

The impingement initiation threshold levels for these materials varied from greater than 10,000 ft/min for M1 dust layer[16] to 38,000 ft/min for TNT[12,13]. For natural gas and fuel oil, thermal, ESD and electrical

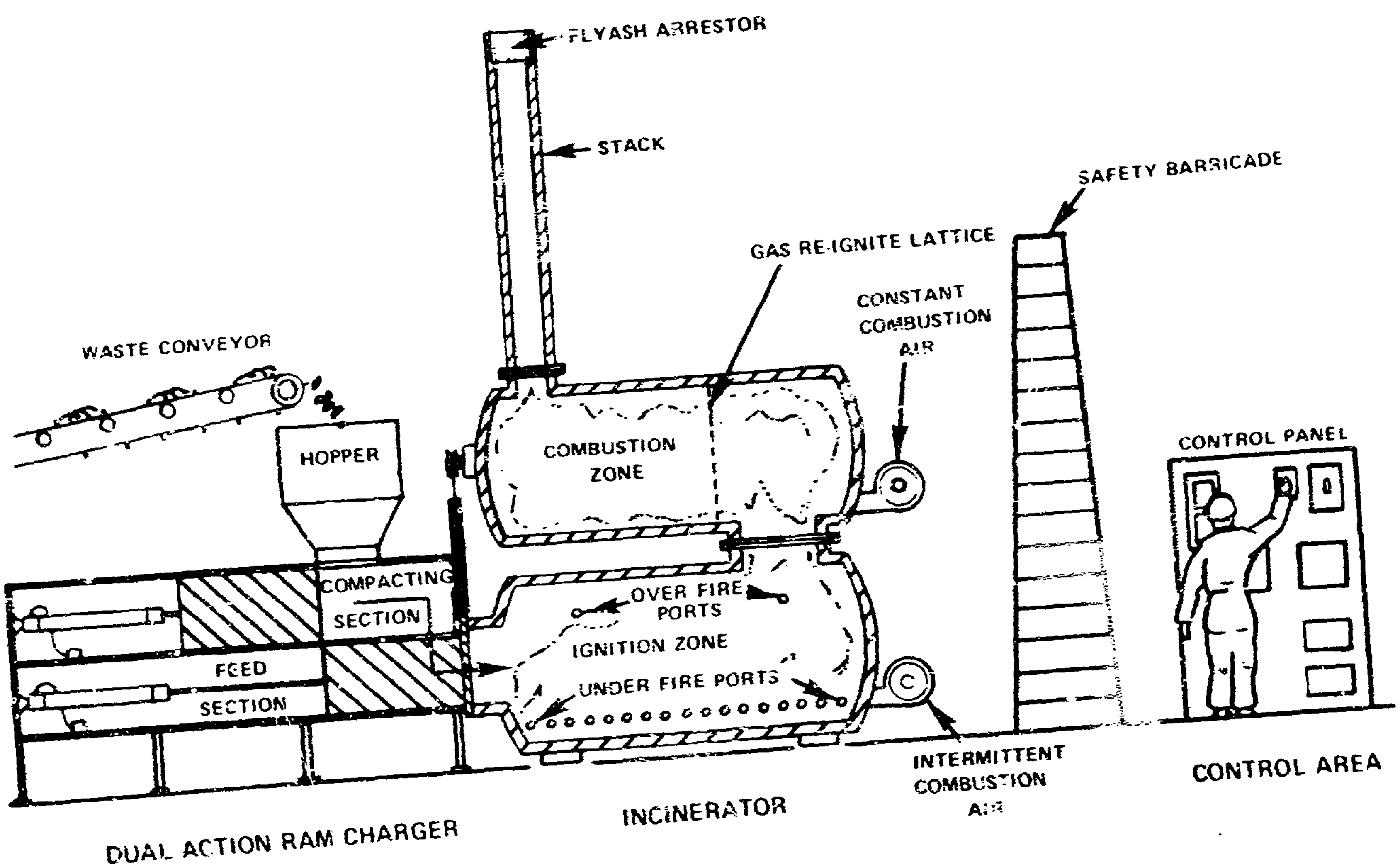

FIGURE III-6

JAAP Contaminated Inert Waste Incinerator
(Environmental Control Products, Inc.)

power discharge were the initiation modes evaluated. Natural gas has an ignition temperature of about 210°C[18] and an electrical ignition threshold of 0.002J[19]. Fuel oil is harder to ignite thermally with an ignition temperature of 482°C[18] but is easier to ignite electrically, requiring only 0.47mj[19].

1. Hopper

The hopper is attached directly to the top of the dual action ram charger and acts as a temporary holding container for the ingredients.

The undesired event could be caused by 77 different minimum sequences of events (minimum cut-sets) as shown in computer simulation of the logic model. Potential initiation modes are summarized in Table III-XXVIII with their safety margins and probabilities and with the maximum probability of sufficient flammable material existing.

Two sequences are unacceptable as considered, based on the 10^{-6} incident probability. Both have an overall probability of 10^{-4} and involve a buildup of an explosive or propellant layer inside the hopper prior to maintenance. A probability of 10^{-4} was assigned to the existence of a sufficient layer since its presence is dependent on the operator not removing contaminants from inert material. An assumption was also made that no check would be made for the presence of a layer of combustible in the hopper prior to maintenance. Thermal or frictional initiation could occur during maintenance. A probability of 1.0 was assigned to this event. The thermal initiation mode during welding would be sufficient to ignite any explosive or propellant. Frictional initiation could occur if a tool is rubbed over a layer of combustible during maintenance. Generation of sufficient energy from a frictional stimulus, however, is dependent on both the stresses developed at a particular applied velocity and the explosive material. By conservatively assuming that the stress was three times the yield strength of SS 316, both M1 and N5 had zero safety margins, and therefore, a probability of 1.0 that the energy generated would be sufficient to ignite a combustible layer. TNT, however, has a positive safety margin (0.51) at this stress and consequently a probability of approximately 10^{-3}. At a stress equal to the yield strength, only N5 had a zero safety margin; M1 and TNT had safety margins of 1.86 and 3.52 respectively with probabilities of 10^{-5} and 10^{-6} respectively, that sufficient energy would be generated.

If an examination was made of the hopper to see whether an explosive layer existed prior to maintenance, and the contaminant was removed, then a 10^{-4} probability would be assigned to the existence of combustible which is subject to initiation by thermal or frictional stimulus during maintenance The overall probability of the undesired event would thus become 10^{-8} and would be classified as an acceptable hazard.

2. Dual Action Ram Charger

The dual action ram charger consists of two piston sections which operate in tandem. The first section is the compacting section. It receives feed from the hopper and crushes the material by forward motion of its piston. The second section is directly below the compacting section and is the feed section. It receives crushed ingredients from the compacting section and pushes them into the furnace by moving its piston forward. These units are equipped with two 3 hp drive motors actuating chain and sprocket driver rams, pressure sensitive switches to prevent jamming and initiate recycling, a flame detection device and controlled water spray for fire protection are also part of the system.

Computer simulation of the logic model identified 98 different minimum sequences of events (minimum cut-sets) for each ram charger which could cause the undesired event. Potential initiation modes are summarized in Table III-XXIX with safety margins and probabilities and with the maximum probability for the existence of sufficient flammable material.

Three sequences are unacceptable, based on the 10^{-6} incident probability. Each had an overall probability of 10^{-4} and required build-up of an explosive or propellant layer inside the charger. The same assumptions were made concerning buildup of this layer as in the hopper. A probability of 10^{-4} was assigned to the existence of a sufficient combustible layer since its presence was dependent on the operator not removing the contaminants from the feed material. In addition, the assumption was made that no check would be made for existence of a combustible layer in the ram charger prior to either maintenance or normal operations. The presence and sufficiency of the same frictional and thermal initiations modes as discussed in the hopper section apply here. Consequently the same corrective action could be taken to make them acceptable hazards. The third initiation stimulus was heat generated by the adjacent furnace. Either periodic cleaning of the system, or not opening the loading door interlock until the temperature was less than 100°C, would be required to make this hazard acceptable.

3. Dual Chamber Furnace

The dual chamber furnace operates as an induced draft incinerator and consists of two vessels positioned horizontally, one over the other. The lower chamber, called the ignition chamber, receives feed from the charger through an interlock loading door which prevents exposing the charger to excessive temperatures. It is equipped with fire ports and an intermittent combustion blower and operates under negative pressure. The second chamber is slightly smaller and is called the combustion chamber. The ignited product is drawn from the lower chamber into the upper chamber. The upper chamber is equipped with a constant combustion air blower and a lattice section for mixing and reigniting the gases.

One hundred twenty-two different minimum sequences of events (minimum cut-sets) were identified, via computer simulation of the logic model, which could cause the undesired event. A summary of potential initiation modes is shown in Table III-XXX with their safety margins and probabilities and with the maximum probability for the presence of sufficient flammable materials.

All 122 sequences had probabilities lower than 10^{-6}. The principal reason for this is the unlikeliness of having a sufficient quantity of fuel, e.g., explosive or natural gas, present. In every instance, at least two failures are necessary for such an occurrence. For a contaminating layer to exist, the operator would have to fail to observe and remove the contaminant (at least a probability of 10^{-4}) and the quantity would have to be sufficient (probability of 10^{-3}). For a dust cloud, the operator would not observe and remove (again at least a probability of 10^{-4}), and the quantity would have to be sufficient and suspended in air (at least accidental 10^{-4} probability). For natural gas or fuel oil to be present, a mechanical failure (10^{-4} probability) is required.

4. Stack

The stack is attached to the top of the combustible chamber of the furnace. At the top of the stack is a stainless steel fly ash arrestor.

Computer simulation of the logic model identified 98 different minimum sequences of events (minimum cut-sets) which could cause the undesired event. Summaries of potential initiation modes with their safety margins and probabilities are shown in Table III-XXXI. The maximum probabilities for the existence of sufficient flammable material are also included.

As with the furnace, all sequences had probabilities below the 10^{-6} level. The principal reason was the difficulty in having sufficient fuel present. Simultaneous triple failures would be required in all instances for the undesired event to occur, since the feed to the stack is the combustion products of the furnace. An additional 10^{-4} probability is assigned to the accidental situation that sufficient fuel, e.g., explosive or natural gas, would not complete combustion in the furnace.

F. Hazards Analysis Summary Tables

The tables in this section present the potential modes of failures and the probabilities associated with each, based on the logic models for each of the four subsystems studied.

To determine the probability of the undesired event, "fire or explosion results in injury or death of personnel, or damage to equipment," for any of the potential failure modes listed, multiply the probability of a combustible being present times y, the probability of a stimulus being of sufficient energy to cause initiation, times z, the probability that the stimulus occurs (this was previously outlined on Figure III-1, page III-5).

Tables for the four systems investigated are presented as indicated below:

TABLES	SYSTEM	PAGES
III-II thru III-VIII	Carbon Adsorption System	III-38 thru III-51
III-IX thru III-XVII	Molecular Sieve System	III-52 thru III-98
III-XVIII thru III-XXVII	Fluidized Bed Incinerator	III-99 thru III-145
III-XXVIII thru III-XXXI	Contaminated Waste Incinerator	III-146 thru III-166

TABLE III- II

Summary of Events Which Can Cause Fire In The Carbon Adsorption Column

(Gate G3C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable TNT or nitrobodies present (G5A)				10^{-6}	
2. Initiation Stimuli				Y	Z
a. Impact (G3E)					
1) Maintenance - Tool strikes combustible	24.2 ft lb/in^2 (12" crescent wrench) 166 ft lb/in^2 (7/16" bolt)	TNT 31.6 ft lb/in^2 Settled TNT (25-30% H_2O) > 72 ft lb/in^2	TNT - 0.31 Wet TNT - 1.98 TNT - 0 TNT - 0	1.0	10^{-4}
2) Tramp Material - metal strikes combustible	Undefined	Same as above	Undefined	1.0	10^{-4}
3) Carbon - movement in carbon bed	Undefined	Same as above	Undefined	1.0	1.0
b. Frictional (G3F)					
1) Maintenance - Tool rubs combustible	42-126 kpsi yields @ 2 ft/sec (316ss	TNT 190kpsi @ 2 ft/sec	TNT (0.51 to 3.52)	10^{-3}	1.0
2) Carbon - movement in carbon bed	Undefined	Settled TNT (25-30% H_2O) > 77.5kpsi @ 8 ft/sec	Undefined	1.0	10^{-3}
c. Thermal (G3G)					
1) Welding	3600°C	TNT 230°C Wet TNT 230°C	TNT (-0.94) Wet TNT(>-0.94)	1.0	1.0

TABLE III-II cont.

Summary of Events Which Can Cause Fire In The Carbon Adsorption Column

(Gate G3C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Fire Adjacent Units	3600°C	Wet TNT > 230°C Dry TNT 230°C	TNT - 0 Wet TNT 0	1.0	10^{-10}
d. ESD (G3H)					
1) Human	0.013J	TNTdust 0.075J Wet TNT 0	TNT (4.77)Wet TNT (95.92)	10^{-7}	10^{-5}
e. Electrical Power (G3I)					
1) Faulty electrical tools	undefined	Same as above	undefined	1.0	10^{-7}
2) Faulty electrical instruments	undefined	Same as above	undefined	1.0	10^{-4}

TABLE III-III

Summary of Events Which Can Cause Fire In The Diatomite Filter

(Gate G6C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable TNT or nitrobodies present (G8A)				10^{-3}	
2. Initiation Stimuli				Y	Z
a. Impact (G6E)					
1) Maintenance - Tool strikes combustible on filter	14.8 ft lb/in² (12" crescent wrench) 101 ft lb/in² 7/16" bolt)	TNT 31.6 ft lb/in² Settled TNT (25-30% H_2O) 72 ft lb/in²	TNT - 1.14 Wet TNT 3.8 TNT - 0 Wet TNT - 0	1.0	10^{-4}
2) Tramp Material - Metal strikes combustible on filter	undefined	same as above	undefined	1.0	10^{-4}
3) Diatomite - Movement of diatomite on filter	undefined	same as above	undefined	1.0	1.0
b. Frictional (G6F)					
1) Maintenance - Tool rubs	42-126kpsi yield @ 2 ft/sec (316ss)	TNT 190kpsi @2ft/sec	TNT (0.51 to3.52)	10^{-3}	1.0
2) Diatomite - Movement on filter	undefined	Settled TNT (25-30% H_2O)> 77.5kpsi @ 8 ft/sec	undefined	1.0	10^{-3}
c. Thermal (G6G)					
1) Welding	ca 3600°C	TNT 230°C Wet TNT>230°C	TNT - 0 Wet TNT 0	1.0	1.0

TABLE III-III cont.

Summary of Events Which Can Cause Fire In The Diatomite Filter

(Gate G6C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Fire Adjacent Units	3600°C	Wet TNT> 230°C TNT - 230°C	TNT - 0 Wet TNT 0	1.0	10^{-10}
d. ESD (G6G)					
1) Human	0.C33J	TNT dust 0.075 Water wet TNT dust 1.26J	TNT (4.77) Wet TNT (35.92)	10^{-7}	10^{-5}
2) Diatomite - Movement during addition	undefined		undefined	1.0	10^{-5}
e. Electrical Power (G6I)					
1) Faulty elect. tools	undefined	same as above	undefined	1.0	10^{-7}
2) Faulty elect. motor	undefined	same as above	undefined	1.0	10^{-4}

TABLE III-IV

Summary of Events Which Can Cause Fire In The Circulating Pump

(Gate G9C)

DESCRIPTION	STRESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY Y	PROBABILITY Z
1. Flammable TNT or Nitrobodies present (G11A)				10^{-4}	
2. Initiation Stimuli					
a. Impact (G9E)					
1) Maintenance - Tool strikes combustible on pump surface	2.7 ft lb/in^2 (12" Crescent wrench) 18.5 ft lb/in^2 (7/16" bolt)	TNT 31.6 ft lb/in^2 Settled TNT (25-30% H_2O) 72 ft lb/in^2	TNT - 10.7 Wet TNT > 25 TNT - .71 Wet TNT 72.9	10^{-3}	10^{-4}
2) Tramp Material - Metal strikes pump walls	undefined	same as above	undefined	1.0	10^{-4}
b. Frictional (G9F)					
1) Maintenance - Tool rubs pump surface	42-126kpsi @ 2 ft/sec (316 SS)	TNT 190 kpsi @ 2 ft/sec	TNT (0.51 to 3.52	10^{-3}	1.0
2) Tramp Material - Rubs combustible	42-126kpsi @ 92ft/sec (316 SS)	Settled TNT (25-30% H_2O) > 77.5 kpsi @ 8 ft/sec	undefined	1.0	10^{-4}
3) Mechanical Movement of pump on combustible	42-126kpsi @ 92 ft/sec (316 SS)		undefined	1.0	10^{-4}
c. Thermal (G9G)					
1) Welding	3600°C	TNT 230°C Wet TNT > 230°C	TNT - 0 Wet TNT 0	1.0	1.0

TABLE III-IV cont.

Summary of Events Which Can Cause Fire In The Circulating Pump

(Gate G9C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Fire Adjacent Units	3600°C	Wet TNT >230°C TNT 230°C	TNT = 0 Wet TNT 0	1.0	10^{-10}
3) Bearing Shaft Overheats	1500°C	same as above	same as above	1.0	10^{-4}
d. ESD (G9H)					
1) Human	0.013J	TNT dust 0.075J Water wet TNT dust 1.26J	TNT (4.77) Water Wet TNT (95.92)	10^{-7}	10^{-5}
e. Electrical Power (G9I)					
1) Faulty elect. tools	undefined	same as above	undefined	1.0	10^{-7}
2) Faulty elect. inst.	undefined	same as above	undefined	1.0	10^{-4}

TABLE III-V

Summary of Events Which Can Cause Fire In The Settling Tank

(Gate G12C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
				Y	Z
1. Flammable TNT or Nitrobodies present (G14A)				10^{-5}	
2. Initiation Stimuli					
a. Impact (G12E)					
1) Maintenance - Tool strikes dried combustible on tank	16.1 ft lb/in^2 (12 inch crescent wrench) 110 ft lb/in^2 (7/16" bolt)	TNT 31.6 ft lb/in^2 Settled TNT(25-30% H_2O) > 72 ft lb/in^2	TNT - 0.96 Wet TNT >3.6 TNT - 0 Wet TNT - 0	1.0	10^{-4}
2) Tramp Metal - Strikes combustible wall	undefined	same as above	undefined	1.0	10^{-4}
b. Frictional (G12F)					
1) Maintenance - Tool rubs tank	42-126kpsi yield@ 2 ft/sec	Settled TNT (25-30% H_2O)>77.5kpsi @ 8ft/sec TNT 190kpsi @ 2 ft/sec	TNT(0.51-3.52)	10^{-3}	1.0
c. Thermal (G12G)					
1) Welding	3600°C	TNT 230°C Wet TNT > 230°C	TNT - 0 Wet TNT 0	1.0	1.0
2) Fire Adjacent Units	3600°C	same as above	same as above	1.0	10^{-10}

TABLE III-V cont.

Summary of Events Which Can Cause Fire In The Settling Tank

(Gate G12C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. ESD (G12H)					
1) Human	0.013J	TNT dust 0.075J Water Wet TNT dust 1.126J	TNT (4.77) Wet TNT (95.9)	10^{-7}	10^{-5}
e. Electrical Power (G12I)					
1) Faulty elect. tool	undefined	same as above	undefined	1.0	10^{-7}
2) Faulty elect. inst.	undefined	same as above	undefined	1.0	10^{-4}

TABLE III-VI

Summary of Events Which Can Cause Fire In The Sump Pump

(Gate G15D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY Y	PROBABILITY Z
1. Flammable TNT or Nitrobodies present (G17A)				10^{-4}	
2. Initiation Stimuli				Y	Z
a. Impact (G15E)					
1) Maintenance - Tool strikes combustible on surface of pump	2.7 ft lb/in^2 (12" Crescent Wrench 18.5 ft lb/in^2 (7/16" bolt)	TNT 31.6 ft lb/in^2 Settled TNT (25-30% H_2O) > 72 ft lb/in^2	TNT - 10.7 Wet TNT 25 TNT - 0.7 Wet TNT 2.9	10^{-3}	10^{-4}
2) Tramp Material - Metal strikes combustible on pump	undefined	same as above	undefined	1.0	10^{-4}
b. Frictional (G15F)					
1) Maintenance - Tool rubs combustible on pump	42-126kpsi yield @ 2 ft/sec (316SS)		TNT (0.51 to 3.5)	10^{-3}	1.0
2) Mechanical movement of pump on combustible	42-126kpsi @92 ft/sec (316 SS)	TNT 190kpsi @ 2 ft/sec	undefined	1.0	10^{-4}
3) Tramp Material- rubs combustible	42-126kpsi @ 92ft/sec (316 SS)	Settled TNT (25-30% H_2O) > 77.5kpsi @ 8 ft/sec	undefined	1.0	10^{-4}
c. Thermal (G15G)					
1) Welding	3600°C	TNT 230°C Wet TNT > 230°C	TNT - 0 Wet TNT 0	1.0	1.0

TABLE III-VI cont.

Summary of Events Which Can Cause Fire In The Sump Pump

(Gate G15D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Fire Adjacent Units	3600°C	Wet TNT > 230°C	TNT = 0	1.0	10^{-10}
3) Bearing Shaft Overheats	1500°C	TNT = 230°C	Wet TNT > 0	1.0	10^{-4}
d. ESD (G15H)					
1) Human	0.013J	TNT dust 0.075J Water wet TNT dust 1.26J	TNT (4.77) Wet TNT (95.92)	10^{-7}	10^{-5}
e. Electrical Power (G15I)					
1) Faulty elect. tools	undefined	same as above	undefined	1.0	10^{-7}
2) Faulty elect. inst.	undefined	same as above	undefined	1.0	10^{-4}

TABLE III-VII

Summary of Events Which Can Cause Fire In The Sump

(Gate G18C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable TNT or Nitrobodies present (G20A)				10^{-5}	
2. Initiation Stimuli				Y	Z
a. Impact (G18E)					
1) Maintenance - Tool strikes sump	6.9 ft lb/in^2 (12" crescent wrench) 47.2 ft lb/in^2 (7/16" bolt)	TNT 31.6 ft lb/in^2 Settled TNT (25-30% H_2O) 72ft lb/in^2	TNT - 3.6 Wet TNT > 9 TNT - 0 Wet TNT > .5	1.0	10^{-4}
2) Tramp Material - strikes sump	undefined	same as above	undefined	1.0	10^{-4}
b. Frictional (G18F)					
1) Maintenance - Tool rubs combustible on sump	42-126kpsi yield @ 2 ft/sec (316SS)	TNT 190kpsi @ 2ft/sec Settled TNT (25-30% H_2O) > 77.5kpsi @ 8 ft/sec	TNT (0.51 to 3.52)	10^{-3}	1.0
c. Thermal (G18G)					
1) Welding	3600°C	TNT 230°C Wet TNT > 230°C	TNT - 0 Wet TNT > 0	1.0	10^{-5}
2) Fire Adjacent Unit	3600°C	TNT 230°C Wet TNT > 230°C	same as above	1.0	10^{-10}

TABLE III -VII cont.

Summary of Events Which Can Cause Fire In The Sump

(Gate G18G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. ESD (G18H)					
1) Human	0.013J	TNT dust 0.075 J Wet TNT 1.26 J	TNT (4.77) Wet TNT (95.92)	10^{-7}	10^{-5}
e. Electrical Power (G18I)					
1) Faulty elect. tools	undefined	TNT dust 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. inst.	undefined	Water Wet TNT dust 1.26J	undefined	1.0	10^{-4}

TABLE III-VIII

Summary of Events Which Can Cause Fire In The Floor Drains

(Gate G21C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable TNT or Nitrobodies present (G23A)				10^{-5}	
2. Initiation Stimuli				Y	Z
a. Impact (G21E)					
1) Maintenance - Tool strikes combustible in floor drain	15.5 ft lb/in^2 (12" crescent wrench) 106 ft lb/in^2 (7/16"bolt)	TNT 31.6 ft lb/in^2 Settled TNT (25-30% H_2O) > 72 ft lb/in^2	TNT - 1.04 Wet TNT -> 3.6 TNT - 0 Wet TNT > 0	1.0	10^{-4}
2) Tramp Material - strikes combustible in drain	undefined	same as above	Undefined	1.0	10^{-4}
b. Frictional (G21F)					
1) Maintenance - Tool rubs	42-126kpsi yield @ 2 ft/sec	TNT 190kpsi @ 2 ft/sec	TNT (0.35 to 3.51)	10^{-3}	1.0
2) Combustible in floor drain		Settled TNT(25-30% H_2O) > 77.5 kpsi @ 2ft/sec	TNT (0.51 to 3.51)	10^{-3}	1.0
c. Thermal (G21G)					
1. Welding	3600°C	TNT 230°C Wet TNT> 230°C	TNT - 0 Wet TNT> 0	1.0	10^{-5}

TABLE III-VIII cont.

Summary of Events Which Can Cause Fire In The Floor Drains

(Gate G21C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Fire Adjacent Units	3600°C	Wet TNT > 230°C TNT - 230°C	TNT - 0 Wet TNT > 0	1.0	10^{-10}
d. ESD (G21H)					
1) Human	0.013J	TNT dust 0.075J Water wet TNT dust 1.26J	TNT (4.77) Wet TNT 95.92	10^{-7}	10^{-5}
e. Electrical Power (G21I)					
1) Faulty elect. tools	undefined	same as above	undefined	1.0	10^{-7}
2) Faulty elect. inst.	undefined	same as above	undefined	1.0	10^{-4}

TABLE III-IX

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE FEED CHILLER ("Off-Gas Cloud - Gate G1C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G2A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G3B)					
1) Condensed or Particulate "off-gas" strikes wall	< 6000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with deposited "off-gas" strikes wall	< 6000 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G3C)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire in Adjacent Units	3600°C	same as above	0	1.0	10^{-10}
c. ESD (G3D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G3E)					
1) Faulty elect. tools	undefined	$NH_4HO_3/HNO_3/H_2O$/oil 0.075 J	undefined	1.0	10^{-7}

TABLE III-IX (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE FEED CHILLER
("Off-Gas" Cloud - Gate G1C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-IX (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE FEED CHILLER
("Off-Gas" Deposit - Gate G4A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface (G5C)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impact (G4C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504 3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil>61.5 ft lb/in^2	0		
1) Maintenance		HNO_3/H_2O/oil>179 Kft lb/sec	0	1.0	10^{-4}
2) Tramp material	same as above	$HNO_3/H_2O/NH_4NO_3$/oil >179Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G4D)		NH_4NO_3/oil >120 kpsi @ 8 ft/sec			
1) Maintenance	42-126kpsi yield @ 2 ft/sec (316SS)	HNO_3/H_2O/oil >106 kpsi @ 8 ft/sec	0	1.0	1.0
		HNO_3/NH_4NO_3/oil >54.4kpsi @ 8 ft/sec			
c. ESD (G4E)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	1.0	10^{-7}

TABLE III-IX (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE FEED CHILLER
("Off-Gas" Deposit - Gate G4A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G4F)					
1) Faulty elect. tools	undefined	NH_4NO_3/HNO_3H_2O/oil 0.075 J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
e. Thermal (G4G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	1.0
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}

TABLE III-X

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE MIST ELIMINATOR
("Off-Gas" Cloud - Gate G1E)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present(G7A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G8B)					
1) Condensed or particulate "off-gas" strikes wall of Mist Eliminator	<6000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with "off-gas" deposit strikes wall of Eliminator	<6000 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G8C)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
c. ESD (G8D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G8E)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}

TABLE III-X (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE MIST ELIMINATOR
("Off-Gas" Cloud - Gate G1E)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-X

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE MIST ELIMINATOR
("Off-Gas" Deposit - Gate G6A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface (G9C)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impact (G6C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil>61.5 ft lb/in^2			
1) Maintenance - Tool strikes mist eliminator		HNO_3/H_2O/oil>179Kft lb/sec	0	1.0	10^{-4}
2) Tramp material - strikes mist eliminator	same as above	HNO_3/NH_4NO_3/oil >179Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G6D)		NH_4NO_3/oil>120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs combustible or mist eliminator	42-126kpsi @ 2 ft/sec	HNO_3/H_2O/oil >106 kpsi @ 8 ft/sec HNO_3/NH_4NO_3/oil >54.4kpsi @ 8 ft/sec	0	1.0	1.0
c. ESD(G6E)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}

TABLE III-X (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE MIST ELIMINATOR
("Off-Gas" Deposition - Gate G6A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G6F)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075 J	undefined	1.0	10^{-4}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-7}
e. Thermal (G6G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	1.0
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}

TABLE III-XI

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING ADSORPTION
("Off-Gas" Cloud - Gate G11B)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G12A)				10^{-9}	
2. Initiation Stimuli				Y	Z
a. Impingement (G13B)					
1) Condensed or particulate "off-gas" strikes wall of vessel	122 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with deposited "off-gas" strikes wall of vessel	122 ft/min		undefined	10^{-16}	10^{-5}
3) Adsorbent/Catalyst with deposited "off-gas" strikes wall of vessel	122 ft/min		undefined	10^{-16}	10^{-3}
b. Thermal (G13C)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Overheating Reg. Compressor and failure (open) reg. valve to Adsorbent/Catalyst vessel	1500°C		0	1.0	10^{-8}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING ADSORPTION ("Off-Gas" Cloud - Gate G11B)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
4) Overheating elect. heater and failure (open) Reg. Valve to Adsorb/Catalyst vessel	1177°C		0	1.0	10^{-8}
c. ESD (G13D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-6}	10^{-5}
d. Electrical Power (G13D)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. inst.	undefined		undefined	1.0	10^{-4}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING ADSORPTION ("Off-Gas" Deposit - Gate G14A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface (G14A)				10^{-7}	
2. Initiation Stimuli				Y	Z
a. Impact (G14C)	178 Kft-lbs/sec or 51.8 ft-lbs/in^2 (12" Crescent Wrench, 1009 Kft-lbs/sec or 354.4 ft-lbs/in^2 (7/16" Bolt)				
1) Maintenance - Tool strikes vessel		NH_4NO_3/oil>61.5 ft lb/in^2	0	1.0	10^{-7}
2) Tramp material - Impacts vessel	same as above	HNO_3/H_2O/oil > 179 Kft lb/sec	0	1.0	10^{-4}
3) Adsorbent/Catalyst - movement against vessel	undefined	H_2O/NH_4NO_3/oil > 179Kft lb/sec	0	10^{-3}	1.0
b. Frictional (G14D)		NH_4NO_3/oil>120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs vessel	42-126kpsi @ 2 ft/sec	HNO_3/H_2O/oil > 106 kpsi @ 8 ft/sec HNO_3/NH_4NO_3/oil >54.4kpsi @ 8 ft/sec	0	1.0	1.0

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING ADSORPTION ("Off-Gas" Deposit - Gate G14A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. ESD(G14E)					
1) Airveying ma [illegible]	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G14[illegible]					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
e. Thermal (G14G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Overheating Reg. Compressor and failure (open) reg. valve to Adsorbent/Catalyst vessel	1500°C		0	1.0	10^{-8}
4) Overheating elect. heater and failure (open) reg. valve to Adsorbent Catalyst vessel	1177°C		0	1.0	10^{-8}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION COOLING ("Off-Gas" Cloud - Gate G27F)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G38A)				10^{-9}	
2. Initiation Stimuli				Y	Z
a. Impingement (G39B)					
1) Condensed or particulate "off-gas" strikes wall of vessel	22 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) "off-gas"contaminated tramp material strike wall of vessel	22 ft/min		undefined	10^{-16}	10^{-5}
3) "off-gas" contaminated Adsorbent/Catalyst strikes wall of vessel	22 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G39C)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire in Adjacent Units	3600°C		0	1.0	10^{-10}
3) Regeneration Compressor overheats and insuffi-ent cooling in Reg. cooler and Gas Chilier	1500°C		0	1.0	10^{-8}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION COOLING ("Off-Gas" Cloud - Gate G27F)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. ESD (G39D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G39E)					
1) Faulty elect. tools	undefined	$NH_4/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION COOLING ("Off-Gas" Deposit - Gate G40A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface (G41G)				10^{-9}	
2. Initiation Stimuli				Y	Z
a. Impact (G40C)					
1) Maintenance - Tool strikes vessel	178 Kft-lbs/sec or 51.8 ft-lbs/in^2 (12" Crescent Wrench) 354.4 ft-lbs/in^2 (7/16" Bolt	NH_4NO_3/oil>61.5 ft lb/in^2	0	1.0	10^{-4}
2) Tramp material - Strikes vessel	same as above	HNO_3/H_2O/oil >179 Kft lb/sec	0	1.0	10^{-4}
3) Adsorbent/Catalyst - moves against vessel walls	undefined	$HNO_3/H_2O/NH_4NO_3$/oil >179Kft lb/sec		10^{-3}	10^{-4}
b. Frictional (G40D)		NH_4NO_3/oil >120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs vessel	42-126kpsi @ 2 ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec HNO_3/NH_4NO_3/oil >54.4kpsi @ 8ft/sec	0	1.0	1.0

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION COOLING
("Off-Gas" Deposit - Gate G40A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. ESD (G40E)					
1) Airveving material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$ 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
e. Thermal (G40G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Regeneration Compressor overheats and insuf. cooling in Reg. Cooler and gas chiller	1500°C		0	1.0	10^{-8}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION HEATING ("Off Gas" Cloud - Gate G49D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G55A)				10^{-9}	
2. Initiation Stimuli				Y	Z
a. Impingement (G56B)					
1) Condensed or particulate "off-gas" strikes wall	36 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with "off-gas" deposit strikes wall	36 ft/min	undefined	undefined	10^{-16}	10^{-5}
3) Adsorbent/Catalyst with "off-gas" deposit strikes wall.	36 ft/min	undefined	undefined	10^{-16}	10^{-3}
b. Thermal (G56C)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Reg. Compressor over-heats	1500°C		0	1.0	10^{-4}
4) Reg. Gas elect. heater overheats	1177°C		0	1.0	10^{-4}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION HEATING
("Off Gas" Cloud - Gate G49D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. ESD (G56D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power					
1) Faulty elect tools	undefined	NH_4NO_3/HNO_3H_2O/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION HEATING ("Off-Gas" Deposit - Gate G58A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface (G57A)				10^{-9}	
2. Initiation Stimuli				Y	Z
a. Impact (G57C)					
1) Maintenance - Tool strikes vessel	178 Kft-lbs/sec or 51.8 ft-lbs/in^2 (12" Crescent Wrench), 504.3 Kft-lbs/sec or 354.4 ft-lbs/in^2 (7/16" Bolt)	NH_4NO_3/oil>61.5 ft lb/in^2	0	1.0	10^{-4}
2) Tramp material. Strikes vessel	same as above	HNO_3/H_2O/oil >179 Kft lb/sec	0	1.0	1.0
3) Adsorbent/Catalyst. Moves and impacts vessel	undefined	$HNO_3/H_2O/NH_4NO_3$/oil >179Kft lb/sec	0	10^{-3}	1.0
b. Frictional (G57D)		NH_4NO_3/oil >120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs vessel	42-126kpsi @ 2ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec HNO_3/NH_4NO_3/oil >54.4kpsi @ 8ft/sec	0	1.0	1.0

TABLE III-XI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE ADSORBENT/CATALYST VESSEL DURING REGENERATION HEATING ("Off-Gas" Deposit - Gate G58A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. ESD(G57E)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
e. Thermal (G57G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	-0.93	1.0	10^{-8}
2) Fire Adjacent Unit	3600°C		-0.93	1.0	10^{-10}
3) Reg. Compressor overheats	1500°C		-0.82	1.0	10^{-4}
4) Reg. Gas elect. heater overheats	1177°C		-0.77	1.0	10^{-4}

TABLE III-XII

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR DURING REGENERATION HEATING
("Off-Gas" Cloud - Gate G11D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G17A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G18B)					
1) Condensed of particulate "off-gas" strikes wall of vessel.	14000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with deposited "off-gas" strikes wall of vessel	14000 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G18C)					
1) Overheated Bearing	1500°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-4}
2) Welding	3600°C		0	1.0	10^{-5}
3) Fire in Adjecent Unit	3600°C		0	1.0	10^{-10}
c. ESD (G18D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}

TABLE III-XII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR
DURING REGENERATION HEATING
("Off-Gas" Cloud - Gate G11D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. Electrical Power (G18E)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
3) Faulty elect. drive	undefined		undefined	1.0	10^{-4}

TABLE III-XII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR DURING REGENERATION HEATING
("Off Gas" Deposit - Gate G19A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface (G20G)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impact (G19C)					
1) Maintenance - Tool strikes compressor	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil >61.5 ft lb/in^2	0	1.0	10^{-4}
2) Tramp material - Impacts compressor	same as above	HNO_3/H_2O/ oil >179 Kft lb/sec $HNO_3/H_2O/NH_4NO_3$/oil >179Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G19D)		NH_4NO_3/oil > 120kpsi			
1) Maintenance - Tool rubs compressor	42-126kpsi @ 2 ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec	0	1.0	1.0
2) Movement of Regen. Compressor on combustible	42-126kpsi @ fps undefined	HNO_3/NH_4NO_3/oil >54.4kpsi @ 8 ft/sec	0	1.0	1.0
c. ESD (G19E)					
1) Airveying "off-gas"	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}

TABLE III-XII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR DURING REGENERATION HEATING
("Off Gas" Deposit - Gate G19A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Airveying Adjacent/ Catalyst	0.025J	HNO_3/H_2O/oil 0.075J	2.00	10^{-6}	10^{-3}
3) Human	0.013J	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G19F)					
1) Faulty elect. tools	undefined		undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
3) Faulty elect. drive	undefined		undefined	1.0	10^{-4}
e. Thermal (G19G)					
1) Overheated bearing due to tramp material	1500°C	HNO_3/water/oil 265°C	0	1.0	10^{-4}
2) Welding	3600°C		0	1.0	10^{-5}
3) Fire in Adjacent Unit	3600°C		0	1.0	10^{-10}

TABLE III-XII

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR DURING REGENERATION COOLING ("Off-Gas" Cloud - Gate G27B)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G28A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G30B)					
1) Condensed or Particulate "off-gas" strikes wall of vessel	14000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with deposited "off-gas" strikes wall of vessel	14000 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G30C)					
1) Overheating bearing	1500°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-4}
2) Welding	3600°C		0	1.0	10^{-5}
3) Fire Adjacent Unit	3600°C		0	1.0	10^{-10}
c. ESD (G30D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G30E)					

TABLE III-XII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR
DURING REGENERATION COOLING
("Off-Gas" Cloud - Gate G27B)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
3) Faulty elect. drive	undefined		undefined	1.0	10^{-4}

TABLE III-XII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR DURING REGENERATION COOLING ("Off-Gas" Deposit - Gate G29A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface (G31G)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impact (G29C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil >61.5ft lb/in^2			
1) Maintenance - Tool strikes compressor		HNO_3/H_2O/oil >179 Kft lb/sec	0	1.0	10^{-4}
2) Tramp material - strikes compressor	same as above	$HNO_3/H_2O/NH_4NO_3$/oil >17[illegible] lb/sec	0	1.0	1.0
b. Frictional (G29D)		NH_4NO_3/oil >120 kpsi @ 8 ft/sec	0		
1) Maintenance - tool rubs compressor	42-126kpsi @ 2ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec	0	1.0	1.0
		HNO_3/NH_4NO_3.oil > 54.4kpsi @ 8ft/sec			
c. ESD (G29E)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}

TABLE III-XII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COMPRESSOR DURING REGENERATION COOLING
("Off-Gas" Deposit - Gate G29A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G29F)					
1) Faulty elect tools	undefined	NH_4NO_3/H_2O/oil 0.075 J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
3) Faulty elect. drive on compressor	undefined		undefined	1.0	10^{-4}
e. Thermal (G29G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Overheating bearing	1500°C		0	1.0	10^{-4}

TABLE III-XIII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS STEAM HEATER ("Off-Gas" Cloud - Gate G49B)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G50A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G51B)					
1) Condensed or Particulate "off-gas" strikes wall	< 6000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with "off-gas" deposit strikes wall	< 6000 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G51C)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Regeneration Compressor overheats	1500°C		0	1.0	10^{-4}
c. ESD (G51D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/ oil 0.075J	4.77	10^{-7}	10^{-5}

TABLE III-XIII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS STEAM HEATER ("Off-Gas" Cloud - Gate G49B)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. Electrical Power (G51E)					
1) Faulty elect. tools	undefined	NH_4NO_3/HNO_3/oil 0.0753	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-XIII

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS STEAM HEATER
("Off-Gas" Deposit: - Gate G52A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY Y	PROBABILITY Z
1. Flammable "off-gas" present on surface (G53F)				10^{-10}	
2. Initiation Stimuli					
a. Impact (G52C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil >61.5 ft lb/in^2			
1) Maintenance - Tool strikes heater		HNO_3/H_2O/oil>179 Kft lb/sec	0	1.0	10^{-4}
2) Tramp material - Strikes heater	same as above	$HNO_3/H_2O/NH_4NO_3$/oil >179Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G52D)		NH_4NO_3/oil>120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs heater	42-126kpsi @ 2ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec	0	1.0	1.0
c. ESD (G52E)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G52F)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}

TABLE III-XIII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS STEAM HEATER ("Off-Gas" Deposit - Gate G52A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Faulty elect. inst.	undefined		undefined	1.0	10^{-4}
e. Thermal (G52G)					
1) Welding	$3600^{\circ}C$	HNO_3/H_2O/oil $265^{\circ}C$	0	1.0	1.0
2) Fire Adjacent Units	$3600^{\circ}C$		0	1.0	10^{-10}
3) Regeneration Compressor overheats	$1500^{\circ}C$		0	1.0	10^{-4}

TABLE III-XIV

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS ELECTRIC HEATER ("Off-Gas Cloud - Gate G11F)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G22A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G23B)					
1) Condensed or particulate off-gas strikes wall of chiller	< 6000ft/mi	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with deposited "off-gas" strikes wall of heater	< 6000ft/mi		undefined	10^{-16}	10^{-5}
b. Thermal (G23C)					
1) Welding	ca3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	ca3600°C		0	1.0	10^{-10}
3) Mech. overheating of Reg. Compressor	1500°C		0	1.0	10^{-4}
4) Primary failure(over-heating) of heater	1177°C		0	1.0	10^{-4}
c. ESD (G23D)					
1) Airveying tramp material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}

TABLE III-XIV (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE
REGENERATION GAS ELECTRIC HEATER
("Off-Gas Cloud - Gate G11F)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G23E)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty electrical instruments	undefined		undefined	1.0	10^{-4}
3) Faulty elect elem. on heater	undefined		undefined	1.0	10^{-4}

TABLE III-XIV

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS ELECTRIC HEATER
("Off-Gas" Deposit - Gate G24A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present on surface(G25F)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impact (G24C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil>61.5 ft lb/in^2			
1) Maintenance - Tool strikes heater		HNO_3/H_2O/oil >179 Kft lb/sec	0	1.0	10^{-4}
2) Tramp metal- Strikes heater walls	same as above	$HNO_3/H_2O/NH_4NO_3$/oil >179 Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G24D)		NH_4NO_3/oil>120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs heater walls	42-126kpsi @ 2ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec HNO_3/NH_4NO_3/oil >54.4 kpsi @ 8ft/sec	0	1.0	1.0
c. ESD (G24E)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}

TABLE III-XIV (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS ELECTRIC HEATER ("Off-Gas" Deposit - Gate G24A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. Electrical Power (G24F)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. insc.	undefined		undefined	1.0	10^{-4}
3) Faulty elect. element in heater	undefined		undefined	1.0	10^{-4}
e. Thermal (G24G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Mech. overheating of Reg. Compressor	1500°C		0	1.0	10^{-4}
4) Primary failure (overheating) of heater	1177°C		0	1.0	10^{-4}

TABLE III-XV

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COOLER
("Off-Gas" Cloud - Gate G27D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable "off-gas" present (G33A)				10^{10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G34B)					
1) Condensed or particulate "off-gas" strikes wall of cooler	< 6000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp Material with deposit	< 6000 ft/min	undefined	undefined	10^{-16}	10^{-5}
b. Thermal (G34C)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Reg. Compressor overheats	1500°C		0	1.0	10^{-4}
c. ESD (G34D)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G34E)					

TABLE III-XV (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COOLER
("Off-Gas" Cloud - Gate G27D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1) Faulty elect. tools	undefined	NH_4NO_3/H_2O/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-XV (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COOLER
("Off-Gas Deposit - Gate G35A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
				10^{-10}	
1. Flammable "off-gas" present on surface (G36G)					
2. Initiation Stimuli				Y	Z
a. Impact (G35C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil >61.5 ft lb/in^2		1.0	10^{-4}
1) Maintenance - Tool strikes cooler		HNO_3/H_2O/oil>179 Kft lb/sec	0		
2) Tramp material - Strikes cooler	same as above	$HNO_3/H_2O/NH_4NO_3$/oil >179Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G35D)					
1) Maintenance - Tool rubs cooler	42-126kpsi @ 2ft/sec	NH_4NO_3/oil > 120kpsi @ 8 ft/sec	0	1.0	1.0
c. ESD (G35E)					
1) Airveying material	0.025J	HNO_3/H_2O/oil>106 kpsi @ 8ft/sec	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/NH_4NO_3/oil >54.4kpsi @8ft/sec	4.77	10^{-7}	10^{-5}

TABLE III-XV (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION COOLER
("Off-Gas"Deposit - Gate G35A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. Electrical Power (G35F)					
1) Faulty electrical tools	undefined	NH_4NO_3/oil 0.50J	undefined	1.0	10^{-7}
2) Faulty electrical instruments	undefined	HNO_3/H_2O/oil 0.075J $NH_4NO_3/HNO_3/H_2O$ 0.075J	undefined	1.0	10^{-4}
e. Thermal (G35G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	1.0
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Reg. Compression overheats	1500°C		0	1.0	10^{-4}

TABLE III-XVI

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS CHILLER
("Off-Gas" Cloud - Gate G49F)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable "off-gas" present (G60A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G61B)					
1) Condensed or Particulate "off-gas" strikes wall	<6000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material work "off-gas" deposit strikes wall	<6000 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G6IC)					
1) Welding	3[illegible]00°C		-0.93	1.0	10^{-5}
2) Fire Adjacent Units	3600°C	HNO_3/H_2O/oil 265°C	-0.93	1.0	10^{-10}
3) Reg. Comp. overheats when either a) insuf. cooling in reg. cooler or, b) failure (open) of valve upstream of chiller during regular heating	1[illegible]00°C		-0.82	1.0	10^{-12}
c. ESD(G61D)		NH_4NO_3/oil 0.50J			

TABLE III-XVI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS CHILLER
("Off-Gas" Cloud - Gate G49F)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1) Airveying material	0.025J	$HNO_3/H_2O/$ oil 0.075J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	$NH_4NO_3/HNO_3/H_2O/$oil 0.0753	4.77	10^{-7}	10^{-5}
d. Electrical Power (G61D)					
1) Faulty elect. tools	undefined		undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-XVI

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE REGENERATION GAS CHILLER
("Off Gas" Deposit - Gate G63A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable "off-gas" present on surface (G63G)				10^{-12}	
2. Initiation Stimuli				Y	Z
a. Impact (G62C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil>61.5 ft lb/in^2			
1) Maintenance - Tool strikes chiller		HNO_3/H_2O/oil >179 Kft lb/sec	0	1.0	10^{-4}
2) Tramp material - Strikes chiller	same as above	$HNO_3/H_2O/NH_4NO_3$/oil >179/Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G62D)		NH_4NO_3/oil>120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs chiller	42-126kpsi @ 2ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec	0	1.0	1.0
c. ESD (G62E)		HNO_3/NH_4NO_3/oil >54.4 kpsi@ 8ft/sec			
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}

* Material Response listed refers to general initiation mode, e.g., ESD and not specific initiation mode, e.g., Human ESD.

TABLE III-XVI (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE
REGENERATION GAS CHILLER
("Off Gas" Deposit - Gate G63A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. Electrical Power (G62F)					
1) Faulty elect. tools	undefined	$NH_4NO_3/HNO_3/H_2O$/oil 0.075 J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
e. Thermal (G62G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	1.0
2) Fire Adjacent Units	3600°C		0	1.0	10^{-10}
3) Regeneration Compression overheats when either insufficient cooling in reg. cooler or failure (open) of valve immediately upstream of chiller during reg. heating	1500°C		0	1.0	10^{-12}

TABLE III-XVII

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE RECYCLE GAS COOLER
("Off Gas" Cloud - Gate G43B)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable "off-gas" present (G44A)				10^{-10}	
2. Initiation Stimuli				Y	Z
a. Impingement (G45B)					
1) Condensed of particulate "off-gas" strikes wall	< 6000 ft/min	undefined	undefined	10^{-16}	10^{-5}
2) Tramp material with "off-gas" deposition strike wall	< 6000 ft/min		undefined	10^{-16}	10^{-5}
b. Thermal (G45C)					
1) Welding	3600°C	HNO_3/oil/H_2O 265°C	.0	1.0	10^{-5}
2) Fire in Adjacent Units	3600°C		.0	1.0	10^{-10}
c. ESD (G45C)					
1) Airveying material	0.025J	NH_4NO_3/ oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/ oil 0.075J	4.77	10^{-7}	10^{-5}
d. Electrical Power (G45E)					
1) Faulty elect. tools	undefined	NH_4NO_3/HNO_3/H_2O/oil 0.075J	undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}

TABLE III-XVII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE RECYCLE GAS COOLER ("Off-Gas" Deposit - Gate G46A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable "off-gas" present on surface (G47G)				10^{-12}	
2. Initiation Stimuli				Y	Z
a. Impact (G46C)	88.8 Kft-lbs/sec or 25.9 ft-lbs/in^2 (12" Crescent wrench) 504.3 Kft-lbs/sec or 177.2 ft-lbs/in^2 (7/16" bolt)	NH_4NO_3/oil>61.5 ft lb/in^2			
1) Maintenance - Tool strikes cooler		HNO_3/H_2O/oil>179 Kft lb/sec	0	1.0	10^{-4}
2) Tramp material - Strikes cooler	same as above	$HNO_3/H_2O/NH_4NO_3$/oil >179Kft lb/sec	0	1.0	10^{-4}
b. Frictional (G46D)		NH_4NO_3/oil>120kpsi @ 8 ft/sec			
1) Maintenance - Tool rubs cooler	42-126kpsi @ 2ft/sec	HNO_3/H_2O/oil>106 kpsi @ 8 ft/sec	0	1.0	1.0
		HNO_3/NH_4NO_3/oil >54.4 kpsi @8ft/sec			
c. ESD (G46E)					
1) Airveying material	0.025J	NH_4NO_3/oil 0.50J	2.00	10^{-6}	10^{-5}
2) Human	0.013J	HNO_3/H_2O/oil 0.075J	4.77	10^{-7}	10^{-5}

TABLE III-XVII (CONT.)

SUMMARY OF SEQUENCES OF EVENTS WHICH CAN CAUSE FIRE IN THE RECYCLE GAS COOLER
("Off-Gas" Deposit - Gate G46A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. Electrical Power (G46F)		$NH_4NO_3/HNO_3/H_2O$/oil 0.075J			
1) Faulty elect. tools	undefined		undefined	1.0	10^{-7}
2) Faulty elect. instruments	undefined		undefined	1.0	10^{-4}
e. Thermal (G46G)					
1) Welding	3600°C	HNO_3/H_2O/oil 265°C	0	1.0	1.0
2) Fire Adjacent Unit	3600°C		0	1.0	10^{-10}

TABLE III-XVIII

Summary of Controlling Factors Which Influence the Initiation of Flammable Material Contaminating Surface of Air Intake Filter Muffler (Gate G2A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable material present on surface (G2B)				10^{-8}	
2. Initiation Stimuli				Y	Z
a. Frictional (G3B)					
1) Maintenance - Tool rubs muffler	42-126 kpsi yield 316 SS @ 2 ft/sec	M1 dust 120 kpsi @ 2 ft/sec	M1 (C) TNT (0.5) N5 (0)	1.0	1.0
2) Tramp Material- Rubs muffler	1-44 psi @ 28 ft/sec (7/16" bolt)	TNT dust 190 kpsi @ 2 ft/sec	Undefined	1.0	10^{-4}
b. Impact (G3C)					
1) Maintenance - Tool strikes muffler	412 ft lb/in^2 (7/16" bolt) 60.2 ft lb$_f$/in^2 (12" crescent wrench)	M1 dust 3.8 ft lb/in^2 S/S TNT dust 31.6 ft lb/in^2 S/S	M1 (0) TNT (0) N5 (0)	1.0	10^{-4}
2) Vibration - impact loose parts or tramp material	Undefined	N5 dust 8.5 ft lb/in^2 S/S	Undefined	1.0	10^{-4}
3) Impingement - Impact from layer breaking free and sticking contaminated surface	4360 ft/min	M1 dust >10000 ft/min TNT dust 38000 ft/min N5 dust 18,700 ft/min	M1 (>1.29) TNT (7.72) N5 (3.29)	10^{-14}	10^{-5}
c. Thermal (G3D)		M1 dust 120°C (24hr) TNT dust 230°C N5 dust 150°C	M1 (0) TNT (0) N5 (0)		
1) Welding	3600°C			1.0	1.0
2) Fire adjacent units	3600°C			1.0	10^{-10}

TABLE III-XVIII cont.

Summary of Controlling Factors Which Influence the Initiation of Flammable Material Contaminating Surface of Air Intake Filter Muffler (Gate G2A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. ESD (G3F)					
1) Airveying material	0.025J	M1 dust 0.013J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J	M1 (0.00) TNT (4.77) N5 (4.77)	10^{-2}	10^{-5}
3) Air through filter medium	Undefined	N5 dust 0.075J	Undefined	1.0	1.0
e. Electrical Power (G3G)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}

TABL III-XVIII cont.

Summary of Controlling Factors which Influence the Initiation of Flammable Cloud from Propellant or Explosive Waste in Air Intake Filter Muffler (G2G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* Y	PROBABILITY* Z
1. Flammable cloud present (G2H)				10^{-13}	
2. Initiation Stimuli				Y	Z
a. Impingement (G3I)					
1) Redirecting flow	4360 ft/min	M1 dust >10000 ft/min	M1(1.29) N5(7.72) N5(3.29)	10^{-14}	10^{-5}
2) Against tramp material	4360 ft/min	TNT dust 38000 ft/min	M1(>1.29) N5(7.72) N5(3.29)	10^{-14}	10^{-5}
3) Turbulent flow	4360 ft/min	N5 dust 18,700 ft/min	M1(>1.29) N5(7.72) N5(3.29)	10^{-14}	10^{-5}
b. Thermal (G3J)					
1) Welding	3600°C	M1 dust 150°C (1 hr)	M1 (0) TNT (0)	1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C	N5 (0)	1.0	10^{-10}
		N5 dust 150°C			
c. ESD (G3L)					
1) Airveying material	0.025J		M1 (0) TNT(2.00) N5(2.00)	1.0	10^{-5}
2) Human	0.013J	M1 dust 0.024J	M1(0.85) TNT(4.77) N5(4.77)	10^{-4}	10^{-8}
3) Air through filter medium	Undefined	TNT dust 0.075J N5 dust 0.075J	Undefined	1.0	1.0
d. Electrical Power (G3M)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}

TABLE III-XIX

Summary of Controlling Factors which Influence the Initiation of Flammable Material Contaminating Surface of Air Blower (G7A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* Y	PROBABILITY* Z
1. Flammable material present on surface (G7B)				10^{-9}	
2. Initiation Stimuli				Y	Z
a. Frictional (G8B)		M1 dust 120Kpsi @ 2 ft/sec TNT dust 190Kpsi @ 2 ft/sec N5 dust 34Kpsi @ 2 ft/sec			
1) Maintenance - Tool rubs surface of blower	42-126 Kpsi yield 316SS @ 2 ft/sec		M1 (0) TNT (0.51) N5 (0)	1.0	1.0
2) Tramp material - Rubs surface	1-44 psi @ 28ft/sec (7/16" bolt)		Undefined	1.0	10^{-4}
3) Mechanical movement of blower on combustible	Undefined		Undefined	1.0	10^{-4}
b. Impact (G8C)		M1 dust 3.8 ft lb/in^2 steel/steel TNT dust 31.6 ft lb/in^2 steel/steel			
1) Maintenance - Tool strikes combustible	412 ft lb/in^2 (7/16" bolt) 60.2 ft lb/in^2 (12" crescent wrench)		M1 (0) TNT (0) N5 (0)	1.0	10^{-4}
2) Vibrations-tramp material or loose parts impact	Undefined	N5 dust 8.5 ft lb/in^2 steel/steel	Undefined	1.0	10^{-4}
3) Impingement-impact from layer breaking free and striking contaminated surface	4360 ft/min	M1 dust >10000 ft/min TNT dust 38000 ft/min N5 dust 18,700 ft/min	M1 (>1.29) TNT (7.72) N5 (3.29)	10^{-14}	10^{-5}
c. Thermal (G8D)		M1 dust 120°C (24 hrs) TNT dust 230°C N5 dust 150°C	M1 (0) TNT (0) N5 (0)		
1) Welding	3600°C			1.0	1.0
2) Fire adjacent units	3600°C			1.0	10^{-10}

TABLE III-XIX cont.

Summary of Controlling Factors Which Influence the Initiation of Flammable Material Contaminating Surface of Air Blower
(Gate G7A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
3) Overheated bearing	$1500^{o}C$	M1 120°C TNT 230°C N5 150°C	M1 (0) TNT (0) N5 (0)	1.0	10^{-4}
d. ESD (G8F)					
1) Airveying material	0.025J	M1 dust 0.013J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J	M1 (0.00) TNT (4.77) N5 (4.77)	10^{-2}	10^{-5}
e. Electrical power (G8G)		N5 dust 0.075J			
1) Faulty elect. tools	Undefined		Undefined	1.0	10^{-7}
2) Improperly grounded blower	Undefined		Undefined	1.0	10^{-4}

TABLE III-XIX cont.

Summary of Controlling Factors Which Influence the Initiation of Flammable Cloud from Propellant or Explosive Waste in Air Blower (Gate G7C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* Y	PROBABILITY* Z
1. Flammable Cloud Present (G7D)				10^{-13}	
2. Initiation Stimuli				Y	Z
A. Impingement (G8I)					
1) Redirecting flow	4360 ft/min	M1 dust >10,000 ft/min	M1 (>1.29) TNT (7.72) N5 (3.29)	10^{-14}	10^{-5}
2) Against tramp material	4360 ft/min	TNT dust 38,000 ft/min	M1 (>1.29) TNT (7.72) N5 (3.29)	10^{-14}	10^{-5}
3) Turbulent flow	4360 ft/min	N5 dust 18,700 ft/min	M1 (>1.29) TNT (7.72) N5 (3.29)	10^{-14}	10^{-5}
B. Thermal (G8J)					
1) Welding	3600°C	M1 dust 150°C (1 hr)	M1 (0)	1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C	TNT (0)	1.0	10^{-10}
3) Overheated bearings	1500°C	N5 dust 150°C	N5 (0)	1.0	10^{-4}
C. ESD (G8L)					
1) Airveying material	0.025 J	M1 dust 0.024 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) human	0.013 J	TNT dust 0.075 J N5 dust 0.075J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
D. Electrical Power (G8M)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}
2) Improperly grounded blower	Undefined		Undefined	1.0	10^{-4}

TABLE III-XIX cont.
Summary of Controlling Factors Which Influence the Initiation of Pilot Gas in Air Blower
(Gate G9C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Pilot Gas Present (G9D)				10^{-12}	
2. Initiation Stimuli				Y	Z
A. ESD (G10C)					
1) Airveying material	0.025 J	0.00047 J	0	1.0	10^{-5}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-8}
B. Electrical Power (G10D)					
1) Faulty Electrical tools	Undefined	0.00047 J	Undefined	1.0	10^{-7}
2) Improperly ground blower	Undefined	0.00047 J	Undefined	1.0	10^{-4}
C. Thermal (G10E)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	10^{-10}
3) Overheated bearings	1500°C	482°C	0	1.0	10^{-4}

TABLE III-XIX cont.

Summary of Controlling Factors Which Influence the Initiation
of Fuel Oil in Air Blower
(Gate G9K)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Fuel Oil Present (G9L)				10^{-12}	
2. Initiation Stimuli				Y	Z
A. ESD (G10I)					
1) Airveying material	0.025 J	0.002	0	1.0	10^{-5}
2) Human	0.013 J	0.002	0	1.0	10^{-8}
B. Electrical Power (G10J)					
1) Faulty electric tools	Undefined	0.002	Undefined	1.0	10^{-7}
2) Improperly ground blower	Undefined	0.002	Undefined	1.0	10^{-4}
C. Thermal (G10H)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	210°C	0	1.0	10^{-10}
3) Overheated bearings	1500°C	210°C	0	1.0	10^{-4}

TABLE III-XX

Summary of Controlling Factors Which Influence the Initiation of Flammable Material Contaminating Surface of Discharge Muffler (Gate G19A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* 10^{-9} Y	Z
1. Flammable Material Present on Surface (G19B)					
2. Initiation Stimuli					
A. Frictional (G21B)					
1) Maintenance - Tool rubs surface	42-120 Kpsi yield (316 SS) at 2 ft/sec	M1 dust 120 Kpsi at 2 ft/sec TNT dust 190 Kpsi at 2 ft/sec N5 dust 34 Kpsi at 2 ft/sec	M1 (-0.05 to 1.86) TNT (0.51 to 3.52) N5 (-0.73 to 0.19)	1.0	1.0
2) Tramp material - Rubs surface	3-170 psi at 26 ft/sec (7/16" bolt)		Undefined	1.0	10^{-4}
B. Impact (G21C)					
1) Maintenance - Tool strikes surface	370 ft-lb/in^2 (7/16" bolt)	M1 dust 3.8 ft-lb/in^2 steel/steel TNT dust 31.6 ft-lb in^2 steel/steel N5 dust 8.5 ft-lb/in^2 steel/steel	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibration - impact loose parts or tramp material	54 ft-lb/in^2 (12" crescent wrench) Undefined		Undefined	1.0	10^{-4}
3) Impingement - Impact from layer breaking free and striking contaminated surface	2215 ft/min	M1 dust >10,000 ft/min TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (>3.51) TNT (16.16) N5 (7.44)	10^{-16}	10^{-5}
C. Thermal (G21D)					
1) Welding	3600°C	M1 dust 120°C (24 hr) TNT dust 230°C N5 dust 150°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
2) Fire adjacent units	3600°C			1.0	10^{-10}

TABLE III-XX cont.

Summary of Controlling Factors Which Influence the Initiation of Flammable Material Contaminating Surface of Discharge Muffler (Gate G19A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
D. ESD (G21F)					
1) Airveying material	0.025 J	M1 dust 0.013 J	M1 (0), TNT (0), N5 (0), M1 (0),	1.0	10^{-5}
2) Human	0.013 J	TNT dust 0.075 J	TNT (4.77)	10^{-2}	10^{-5}
		N5 dust 0.075 J	N5 (4.77)		
E. Electrical power (G21G)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}

TABLE III-XX cont.

Summary of Controlling Factors Which Influence the Initiation of Flammable Cloud from Propellant or Explosive Wastes in Discharge Muffler (Gate G19C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Cloud Present (G19D)				10^{-13}	
2. Initiation Stimuli				Y	Z
A. Impingement (G21I)					
1) Redirecting flow	2215 ft/min	M1 dust >10,000 ft/min	M1 (>3.51) TNT (16.16) N5 (7.44)	10^{-16}	10^{-5}
2) Against tramp material	2215 ft/min	TNT dust 38,000 ft/min	M1 (>3.51) TNT (16.16) N5 (7.44)	10^{-16}	10^{-5}
3) Turbulent flow	2215 ft/min	N5 dust 18,700 ft/min	M1 (>3.51) TNT (16.16) N5 (7.44)	10^{-16}	10^{-5}
B. Thermal (G21J)					
1) Welding	3600°C	M1 dust 150°C (1 hr)	M1 (0) TNT (0) N5 (0)	1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C N5 dust 150°C		1.0	10^{-10}
C. ESD (G21L)					
1) Airveying material	0.025 J	M1 dust 0.024 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013 J	TNT dust 0.075 J N5 dust 0.075J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
D. Electrical (G21M)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}

TABLE III-XX cont.

Summary of Controlling Factors Which Influence the Initiation of Pilot Gas in Discharge Muffler (Gate G22A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Pilot Gas Present (G22B)				10^{-16}	
				Y	Z
2. Initiation Stimuli					
A. ESD (G23C)					
1) Airveying material	0.025 J	0.00047 J	0	1.0	10^{-5}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-8}
B. Electrical Power (G23D)					
1) Faulty electric tools	Undefined	0.00047 J	Undefined	1.0	10^{-7}
C. Thermal (G23E)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire in adjacent units	3600°C	482°C	0	1.0	10^{-10}

TABLE III-XX cont.

Summary of Controlling Factors Which Influence the Initiation of Fuel Oil in Discharge Muffler (Gate G22G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Fuel Oil Present (G22H)				10^{-16}	
				Y	Z
2. Initiation Stimuli					
A. ESD (G23H)					
1) Airveying material	0.025 J	0.002 J	0	1.0	10^{-5}
2) Human	0.013 J	0.002 J	0	1.0	10^{-8}
B. Electrical Power (G23I)					
1) Faulty electric tools	Undefined	0.002 J	Undefined	1.0	10^{-7}
C. Thermal (G23J)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	210°C	0	1.0	10^{-10}

TABLE III-XXI

Summary of Controlling Factors Which Influence the Initiation of Sufficient Pilot Gas in Burner (Gate G32C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Pilot Gas Present (G32D)				10^{-4}	
				Y	Z
2. Initiation Stimuli					
A. ESD (G37C)					
1) Airveying material	0.025 J	0.00047 J	0	1.0	10^{-5}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-8}
3) Flowing pilot gas	Undefined	0.00047 J	Undefined	10^{-4}	10^{-5}
4) Flowing fuel oil	Undefined	0.00047 J	Undefined	10^{-4}	10^{-5}
B. Electrical Power (G37D)					
1) Faulty electric tools	Undefined	0.00047 J	Undefined	1.0	10^{-7}
C. Thermal (G37E)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	1.0
3) Normally occurring fire	3600°C	482°C	0	1.0	1.0
4) Residual heat	630°C	482°C	0	1.0	1.0

TABLE III-XXI cont.

Summary of Controlling Factors Which Influence the Initiation of Sufficient Fuel Oil in Burner (Gate G33A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Sufficient Flammable Fuel Oil Present (G33B)				10^{-4}	
2. Initiation Stimuli				Y	Z
A. ESD (G37H)					
1) Airveying material	0.025 J	0.002 J	0	1.0	10^{-5}
2) Human	0.013 J	0.002 J	0	1.0	10^{-8}
3) Flowing pilot gas	Undefined	0.002 J	Undefined	10^{-4}	10^{-5}
4) Flowing fuel oil	Undefined	0.002 J	Undefined	10^{-4}	10^{-5}
B. Electrical Power (G37I)					
1) Faulty electric tools	Undefined	0.002 J	Undefined	1.0	10^{-7}
C. Thermal (G37J)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	210°C	0	1.0	1.0
3) Normally occurring fire	3600°C	210°C	0	1.0	1.0
4) Residual heat	630°C	210°C	0	1.0	1.0

TABLE III-XXI cont.

Summary of Controlling Factors Which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Burner (Gate G33H)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* Y	PROBABILITY* Z
1. Flammable Material Present on Surface (G33I)				10^{-13}	
2. Initiation Stimuli				Y	Z
A. Frictional (G35B)					
1) Maintenance - Tool rubs surface	42-126 Kpsi 316 SS yield at 2 ft/sec	M1 dust 120 Kpsi at 2 ft/sec TNT dust 190 Kpsi at 2 ft/sec N5 dust 34 Kpsi at 2 ft/sec	M1 (0) TNT (0.51) N5 (0)	1.0	1.0
2) Tramp material Rubs surface	1-44 psi at 16 ft/sec (7/16" bolt)		Undefined	1.0	10^{-4}
B. Impact (G35C)					
1) Maintenance - Tool strikes surface	142 ft-lb/in^2 (7/16" bolt) 20.7 ft-lb/in^2 (16" crescent wrench)	M1 dust 3.8 ft-lb/in^2 S/S TNT dust 31.6 ft-lb/in^2 S/S N5 dust 8.5 ft-lb/in^2 S/S	M1 (0) TNT (0.53) N5 (0)	1.0	10^{-4}
2) Vibration - impact loose parts or tramp material	Undefined		Undefined	1.0	10^{-4}
3) Impingement - impact from layer breaking free and st striking contaminated surface	6280 ft/min	M1 dust >10,000 ft/min TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (>0.59) TNT (5.05) N5 (1.98)	10^{-8}	10^{-5}

TABLE II-XXI cont.

Summary of Controlling Factors Which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Burner (Gate G33H)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
C. Thermal (G35D)					
1) Welding	3600°C	M1 dust 120°C (24 hr)		1.0	1.0
2) Fire adjacent units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C		1.0	1.0
4) Residual heat	630°C			1.0	1.0
D. ESD (G35F)					
1) Airveying material	0.025 J	M1 dust 0.013 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013 J	TNT dust 0.075 J	M1 (0.00) TNT (4.77) N5 (4.77)	10^{-2}	10^{-5}
3) Flowing pilot gas	Undefined	N5 dust 0.075 J	Undefined	10^{-4}	10^{-5}
4) Flowing fuel oil	Undefined		Undefined	10^{-4}	10^{-5}
E. Electrical Power (G35G)					
1) Faulty electric tools	Undefined	same as above	Undefined	1.0	10^{-7}

TABLE III-XXI

Summary of Controlling Factors Which Influence the Initiation of Sufficient Flammable Cloud from Propellant or Explosive Waste in Burner (Gate G34A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Cloud Present (G34B)				10^{-13}	
2. Initiation Stimuli				Y	Z
A. Impingement (G36B)					
1) Redirecting flow	6280 ft/min	M1 dust >10,000 ft/min	M1 (>0.59) TNT (5.05) N5 (1.98)	10^{-8}	10^{-5}
2) Tramp material	6280 ft/min	TNT dust 38,000 ft/min	M1 (>0.59) TNT (5.05) N5 (1.98)	10^{-8}	10^{-5}
3) Turbulent flow	6280 ft/min	N5 dust 18,700 ft/min	M1 (>0.59) TNT (5.05) N5 (1.98)	10^{-8}	10^{-5}
B. Thermal (G36C)					
1) Welding	3600°C	M1 dust 150°C (1 hr)		1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C		1.0	1.0
4) Residual heat	630°C			1.0	1.0
C. ESD (G36E)					
1) Airveying material	0.025 J	M1 dust 0.024 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013 J	TNT dust 0.075 J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
3) Flowing pilot gas	Undefined	N5 dust 0.075 J	Undefined	10^{-4}	10^{-5}
4) Flowing fuel oil	Undefined		Undefined	10^{-4}	10^{-5}
D. Electrical Power					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}

D

TABLE III-XXII

Summary of Controlling Factors Which Influence the Initiation of Sufficient Pilot Gas in Preheater (Gate G45C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Pilot Gas Present (G45D)				10^{-12}	
				Y	Z
2. Initiation Stimuli					
A. ESD (G47C)					
1) Airveying material	0.025 J	0.00047 J	0	1.0	10^{-5}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-8}
3) Flowing pilot gas	Undefined	0.00047 J	Undefined	10^{-4}	10^{-5}
4) Flowing fuel oil	Undefined	0.00047 J	Undefined	10^{-4}	10^{-5}
B. Electrical Power (G47D)					
1) Faulty electric tools	Undefined	0.00047 J	Undefined	1.0	10^{-7}
2) Faulty controllers (temp. and flame guard)	Undefined	0.00047 J	Undefined	1.0	10^{-5}
C. Thermal (G47E)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	1.0
3) Normally occurring fire	3600°C	482°C	0	1.0	1.0
4) Residual heat	630°C	482°C	0	1.0	1.0

TABLE III-XXII cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient
Fuel Oil in Preheater
(Gate G45J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable fuel oil present (G45K)				10^{-12}	
2. Initiation Stimuli				Y	Z
a. ESD (G47H)					
1) Airveying Material	0.025J	0.002J	0	1.0	10^{-5}
2) Human	0.013J	0.002J	0	1.0	10^{-8}
3) Flowing Pilot Gas	Undefined	0.002J	Undefined	10^{-4}	10^{-5}
4) Flowing Fuel Oil	Undefined	0.002J	Undefined	10^{-4}	10^{-5}
b. Electrical Power (G47I)					
1) Faulty Electrical Tools	Undefined	0.002J	Undefined	1.0	10^{-7}
2) Faulty Controllers (Temperature and flame guard)	Undefined	0.002J	Undefined	1.0	10^{-4}
c. Thermal (G47E)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C	210°C	0	1.0	1.0
3) Normally Occurring Fire	3600°C	210°C	0	1.0	1.0
4) Residual Heat	630°C	210°C	0	1.0	1.0

TABLE III-XXII cont.

SUMMARY OF CONTROLLING FACTORS WHICH INFLUENCE THE INITIATION OF SUFFICIENT FLAMMABLE MATERIAL CONTAMINATING SURFACE OF PREHEATER (GATE G46A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* Y	PROBABILITY* Z
1. Flammable material present on surface (G46D)				10^{-13}	
2. Initiation Stimuli				Y	Z
a. Frictional (G48B) 1) Maintenance - Tool rubs surface	42-126 Kpsi yield 316SS @ 2 ft/sec	M1 dust 120 Kpsi @ 2 ft/sec; TNT dust 190 Kpsi @ 2 ft/sec; N5 dust 34 Kpsi @ 2 ft/sec	M1 (0) TNT (0.5 to 3.52) N5 (0)	1.0	1.0
2) Tramp Material - Rubs surface	1-44 psi @ 32 ft/sec (7/16 in. bolt)		Undefined	1.0	10^{-4}
b. Impact (G48C)	$567 ft-lb/in.^2$ (7/16 in. bolt)				
1) Maintenance - Tool strikes surface	$82.4 ft-lb/in.^2$ (12 in. crescent wrench)	M1 dust 3.8 ft-lb/$in.^2$ steel/steel; TNT dust 31.6 ft-lb/$in.^2$ steel/steel; N5 dust 8.5 ft lb/$in.^2$ steel/steel	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibration - Impact loose parts or tramp material	Undefined		Undefined	1.0	10^{-4}
3) Impingement - Impact from layer breaking free and striking contaminating surface	2790 ft/min	M1 dust > 10,000 ft/min; TNT dust 38,000 ft/min; N5 dust 18,700 ft/min	M1 (2.58) TNT (12.62) N5 (5.70)	10^{-16}	10^{-5}
c. Thermal (G48D) 1) Welding	3600°C	M1 dust 120°C (24 hr); TNT dust 230°C; N5 dust 150°C		1.0	1.0
2) Fire adjacent units	3600°C		M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C			1.0	1.0
4) Residual heat	630°C			1.0	1.0

TABLE III-XXII cont.

SUMMARY OF CONTROLLING FACTORS WHICH INFLUENCE THE INITIATION OF SUFFICIENT FLAMMABLE MATERIAL CONTAMINATING SURFACE OF PREHEATER (GATE G46A) (CONT.)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
d. ESD (G48F)					
1) Airveying material	0.025J	M1 dust 0.013J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J	M1 (0.00) TNT (4.77) N5 (4.77)	10^{-2}	10^{-5}
3) Flowing pilot gas	Undefined	N5 Paste dust 0.075J	Undefined	10^{-4}	10^{-5}
4) Flowing fuel oil	Undefined		Undefined	10^{-4}	10^{-5}
e. Electrical Power (G48G)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}
2) Faulty controllers (Temp. - flame guard)	Undefined		Undefined	1.0	10^{-4}

TABLE III-XXII cont.

SUMMARY OF CONTROLLING FACTORS WHICH INFLUENCES THE INITIATION OF SUFFICIENT FLAMMABLE CLOUD FROM PROPELLANT OR EXPLOSIVE MATERIAL IN PREHEATER (GATE G46C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* Y	PROBABILITY* Z
1. Flammable cloud present (G46D)				10^{-13}	
2. Initiation Stimulus					
a. Impingement (G49B)					
1) Redirecting flow	2790 ft/min	M1 dust >10000 ft/min	M1 (2.58) TNT (12.62) N5 (5.70)	10^{-16}	10^{-5}
2) Tramp material	2790 ft/min	TNT dust 3800 ft/min	M1 (2.58) TNT (12.62) N5 (5.70)	10^{-16}	10^{-5}
3) Turbulent flow	2790 ft/min	N5 dust 18,700 ft/min	M1 (2.58) TNT (12.62) N5 (5.70)	10^{-16}	10^{-5}
b. Thermal (G49C)					
1) Welding	3600°C	M1 dust 150°C (1hr)		1.0	10^{-5}
2) Fire Adjacent Units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C		1.0	1.0
4) Residual Heat	630°C			1.0	1.0
c. ESD (G49E)					
1) Airveying material	0.025J	M1 0.024 J TNT 0.075J N5 0.075J	M1 (-0.04) TNT (2.00) N5 (2.00)	1.0	10^{-5}

TABLE III - XXII cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Cloud from Propellant or Explosive Material in Preheater (Gate G46C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Human	0.013J	M1 dust 0.024J	M1 (0.85) TNT (4.77) N5 ([illegible].77)	10^{-4}	10^{-8}
3) Flowing pilot gas	undefined	TNT dust 0.075J	undefined	10^{-4}	10^{-5}
4) Flowing fuel oil	undefined	N5 dust 0.075J	undefined	10^{-4}	10^{-5}
d. Electrical power (G49F)					
1) Faulty electrical tools	undefined		undefined	1.0	10^{-7}
2) Faulty controllers (temp and flame guard)	undefined		undefined	1.0	10^{-4}

TABLE III-XXIII

SUMMARY OF CONTROLLING FACTORS WHICH INFLUENCE THE INITIATION OF SUFFICIENT OIL IN PLENUM (GATE G59C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable fuel oil is present (G59D)				10^{-16}	
2. Initiation Stimuli				Y	Z
a. ESD (G61H)					
1) Airveying material	0.025J	0.002J	0	1.0	10^{-5}
2) Human	0.013J	0.002J	0	1.0	10^{-8}
b. Electrical Power (G61I)					
1) Faulty electrical tools	Undefined	0.002J	Undefined	1.0	10^{-7}
2) Faulty process indicators (pressure and temperature)	Undefined	0.002J	Undefined	1.0	10^{-4}
c. Thermal (G61J)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire in adjacent units	3600°C	210°C	0	1.0	1.0
3) Normally ocurring fire	3600°C	210°C	0	1.0	1.0
4) Residual heat	630°C	210°C	0	1.0	1.0

TABLE III-XXIII cont.

SUMMARY OF CONTROLLING FACTORS WHICH INFLUENCE THE INITIATON
OF SUFFICIENT PILOT GAS IN PLENUM
(GATE G59J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
1. Flammable pilot gas is present (G59K)				10^{-16}	
2. Initiation Stimuli				Y	Z
a. ESD (G61C)					
1) Airveying material	0.025J	0.00047J	0	1.0	10^{-5}
2) Human	0.013J	0.00047J	0	1.0	10^{-8}
b. Electrical Power (G61D)					
1) Faulty electrical tools	Undefined	0.00047J	Undefined	1.0	10^{-7}
2) Faulty process indicator (pressure and temperature)	Undefined	0.00047J	Undefined	1.0	10^{-4}
c. Thermal (G61E)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	1.0
3) Normally occurring fire	3600°C	482°C	0	1.0	1.0
4) Residual heat	630°C	482°C	0	1.0	1.0

TABLE III-XXIII cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Plenum (Gate G60A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* X	PROBABILITY* Z
1. Flammable material present on surface (G60B)				10^{-8}	
2. Initiation Stimuli					
a. Frictional (G62B)					
1) Maintenance	42-126Kpsi yield 316SS @ 2 ft/sec	M1 dust 120 Kpsi @ 2 ft/sec.	M1 (0) TNT (0.51 to 3.52) N5 (0)	1.0	1.0
2) Tramp Material	1-44 psi @ 23ft/sec. (7/16" bolt)	TNT dust 190 Kpsi @ 2ft/sec	undefined	1.0	10^{-4}
b. Impact (G62C)	283 ft lb/in.^{2} (7/16" bolt)	N5 dust 34Kpsi @ 2ft/sec.			
1) Maintenance	41.4 ft lb/in.^{2} (12" crescent wrench)		M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibration - impact loose parts or tramp material	undefined	M1 dust 3.8 ft lb/in.^{2} steel/steel TNT dust 31.6 ft lb/in.^{2} steel/steel N5 dust 8.5 ft lb/in.^{2} steel/steel	undefined	1.0	10^{-4}
3) Impingement - Impact from layer breaking free and striking Contaminated Surface	5330 ft/min	M1 dust >10000ft/min TNT dust 38000ft/min N5 dust 18700 ft/min	M1 (0.88) TNT (6.13) N5 (2.51)	10^{-10}	10^{-4}

TABLE III-XXIII cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Plenum (Gate G60A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. Thermal (G6?D)					
1) Welding	3600°C	M1 dust 120°C (2hrs)		1.0	1.0
2) Fire Adjacent Units	3600°C	TNT dust 230°C		1.0	1.0
3) Normally Occurring Fire	3600°C	N5 dust 150°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
4) Residual Heat	630°C			1.0	1.0
d. ESD (G62F)					
1) Airveying material	0.0025J	M1 dust 0.013J	M1 (0) TNT(2.00) N5(2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J	M1(0.00) TNT(4.77) N5(4.77)	10^{-2}	10^{-5}
e. Electrical Power (G62G)		N5 dust 0.075J			
1) Faulty elect. tools	undefined		undefined	1.0	10^{-7}
2) Faulty process indicators (pressure and temp)	undefined		undefined	1.0	10^{-4}

TABLE III-XXIII

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Cloud from Propellant or Explosive Material in Plenum (Gate G60C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* X	PROBABILITY* Z
1. Flammable cloud present (G60D)				10^{-8}	
2. Initiation Stimuli				X	Z
a. Impingement (G63B) 1) Redirecting flow	5330 ft/min	M1 dust >10000 ft/min	M1(>0.88) TNT(6.13) N5(2.51)	10^{-10}	10^{-4}
2) Against tramp material	5330 ft/min	TNT dust 38000 ft/min	M1(>0.88) TNT(6.13) N5(2.51)	10^{-10}	10^{-4}
3) Turbulent flow	5330 ft/min	N5 dust 18,700 ft/min	M1(>0.88) TNT(6.13) N5(2.51)	10^{-10}	10^{-4}
4) Against Alumina Bed Material	5330 ft/min		M1(>0.88) TNT(6.13) N5(2.51)	10^{-10}	10^{-4}
b. Thermal (G63C) 1) Welding	3600°C	M1 dust 150°C (1 hr		1.0	10^{-5}
2) Fire Adjacent Units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C		1.0	1.0
4) Residual Heat	630°C			1.0	1.0

TABLE III-XXIII cont.

SUMMARY OF CONTROLLING FACTORS WHICH INFLUENCES THE INITIATION OF SUFFICIENT FLAMMABLE CLOUD FROM PROPELLANT OR EXPLOSIVE MATERIAL IN PLENUM (GATE G60C) (CONT.)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY Y	PROBABILITY Z
c. ESD (G63E)					
1) Airveying material	0.025J	M1 dust 0.024J	M1 (0) TNT(2.00) N5(2.00)	1.0	10^{-5}
		N5 dust 0.075 J			
2) Human	0.013J	TNT dust 0.075J	M1(0.85) TNT(4.77) N5(4.77)	10^{-4}	10^{-8}
d. Electrical Power (G63F)					
1) Faulty elect. tools	undefined		undefined	1.0	10^{-7}
2) Faulty process indicators (pressure and temp)	undefined		undefined	1.0	10^{-4}

TABLE III-XXIV

Summary of Controlling Factors which Influence the Initiation of Sufficient
Fuel Oil in Grid
(Gate G73C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable fuel oil present (G73D)				10^{-16}	
2. Initiation Stimuli				Y	Z
a. ESD (G75H)					
1) Airveying material	0.025J	0.002J	0	1.0	10^{-5}
2) Human	0.013J	0.002J	0	1.0	10^{-8}
b. Electrical Power (G75I)					
1) Faulty electrical tools	Undefined	0.002J	Undefined	1.0	10^{-7}
c. Thermal (G75J)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	210°C	0	1.0	1.0
3) Normally occurring fire	3600°C	210°C	0	1.0	1.0
4) Residual heat	630°C	210°C	0	1.0	1.0

TABLE III-XXIV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient
Pilot Gas in Grid
(Gate G73J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable pilot gas present (G73K)				10^{-20}	
2. Initiation Stimuli				Y	Z
a. E[illegible] (G75C)					
1) Airveying material	0.025J	0.00047J	0	1.0	10^{-5}
2) Human	0.013J	0.00047J	0	1.0	10^{-8}
b. Electrical Power (G75D)					
1) Faulty elect. tools	undefined	0.00047J	undefined	1.0	10^{-7}
c. Thermal (G75E)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent Units	3600°C	482°C	0	1.0	1.0
3) Normally occurring fire	3600°C	482°C	0	1.0	1.0
4) Residual Heat	630°C	482°C	0	1.0	1.0

TABLE III-XXIV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Grid
(Gate G74A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
				Y	Z
1. Flammable material present on surface (G74B)				10^{-8}	
2. Initiation Stimuli a. Frictional (G76B)		M1 dust 120Kpsi @ 2ft/sec	M1 (0) TNT (0.51 to 3.52) N5 (0)	1.0	1.0
1) Maintenance - Tool rubs surface	42-126Kpsi yield 316SS@2ft/sec	TNT dust 190Kpsi @ 2ft/sec			
2) Tramp material - Ribs surface	1-44psi @ 45 ft/sec 7/16" bolt	N5 dust 34 Kpsi @ 2ft/sec	undefined	1.0	10^{-4}
b. Impact (G76C) 1) Maintenance - Tool strikes surface	1110 ft lb/in^2 7/16" bolt 162 ft lb/in^2 (12" crescent wrench)	M1 dust 3.8 ft lb/in^2 steel/steel	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibration-impact loose parts or tramp material	undefined	TNT dust 31.6 ft lb/in^2 steel/steel N5 dust 8.5 ft-lbs/in^2 (S/S)	undefined	1.0	10^{-4}
3) Impingement - Impact from layer breaking free and striking Contaminated Surface	35000 ft/min	M1 dust >10000 ft/min TNT dust 38000 ft/min N5 dust 150°C	M1 (0.71) TNT (0.09) N5 (0)	1.0	10^{-3}
c. Thermal (G76D) 1) Welding	3600°C	M1 dust 120°C(24hr) TNT dust 230°C N5 dust 150°C	M1 (0), TNT (0), N5 (0)	1.0	1.0

TABLE III-XXIV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Grid (Gate G74A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
				Y	Z
2) Fire Adjacent Units	3600°C	M1 120°C TNT dust 230°C	M1 (0), TNT (0), N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C	M1 (0), TNT (0), N5 (0)	1.0	1.0
4) Residual Heat	630°C		M1 (0), TNT (0), N5 (0)	1.0	1.0
d. ESD (G76F) 1) Airveying material	0.025J	M1 dust 0.013J N5 dust 0.075 J	M1 (0) TNT(2.00) N5(2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J	M1(0.00)TNT(4.77) N5(4.77)	10^{-2}	10^{-5}
e. Electrical Power (G76G)					
1) Faulty elect. tools	undefined		undefined	1.0	10^{-7}

TABLE III-XXIV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Cloud from Propellant or Explosive Material in Grid (Gate G74C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* 10^{-8} Y	Z
1. Flammable cloud present (G74D)					
2. Initiation Stimuli				Y	Z
a. Impingement (G77B)					
1) Redirecting flow	35,000 ft/min	M1 dust > 10,000 ft/min	M1 (0) TNT (0.09) N5 (0)	1.0	10^{-3}
2) Against tramp material	35,000 ft/min	TNT dust 38,000 ft/min	M1 (0) TNT (0.09) N5 (0)	1.0	10^{-3}
3) Turbulent flow	35,000 ft/min	N5 dust 18,700 ft/min	M1 (0) TNT (0.09) N5 (0)	1.0	10^{-3}
4) Against alumina bed	35,000 ft/min		M1 (0) TNT (0.09) N5 (0)	1.0	10^{-3}
b. Thermal (G77C)					
1) Welding	3600°C	M1 dust 150°C (1 hr	M1 (0), TNT (0) N5 (0)	1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
4) Residual heat	630°C		M1 (0) TNT (0.63) N5 (0)	1.0	1.0
c. ESD (G77E)					
1) Airveying material	0.025J	M1 dust 0.024J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J N5 dust 0.075J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
d. Electrical Power (G77F)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}

TABLE III-XXV

Summary of Controlling Factors which Influence the Initiation of Sufficient
Flammable Fuel Oil in Bed
(Cate G85C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* 10^{-12} Y	Z
1. Flammable fuel oil present (G85D)					
2. Initiation Stimuli				Y	Z
a. ESI (G87C)					
1) Ai[illegible]veying material	0.025J	0.002J	0	1.0	10^{-5}
2) Human	0.013J	0.002J	0	1.0	10^{-8}
b. Electrical Power (G87D)					
1) Faulty electrical tools	Undefined	0.002J	Undefined	1.0	10^{-7}
2) Faulty instrumentation (temp. and pressure indicators)	Undefined	0.002J	Undefined	1.0	10^{-4}
c. Thermal (G87E)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	210°C	0	1.0	1.0
3) Normally occurring fire	3600°C	210°C	0	1.0	1.0
4) Residual heat	930°C	210°C	0	1.0	1.0

TABLE III-XXV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient
Pilot Gas in Bed
(Gate G85J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable pilot gas present (G85K)				10^{-24}	
2. Initiation Stimuli				Y	Z
a. ESD (G87H)					
1) Airveying material	0.025J	0.00047J	0	1.0	10^{-5}
2) Human	0.013J	0.00047J	0	1.0	10^{-8}
b. Electrical Power (G87I)					
1) Faulty electrical tools	Undefined	0.00047J	Undefined	1.0	10^{-7}
2) Faulty instrumentation (temp. and pressure indicators)	Undefined	0.00047J	Undefined	1.0	10^{-4}
c. Thermal (G87J)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	1.0
3) Normally occurring fire	3600°C	482°C	0	1.0	1.0
4) Residual heat	930°C	482°C	0	1.0	1.0

TABLE III-XXV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Bed (Gate G86A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable material present on surface (G86B)				10^{-8}	
2. Initiation stimuli				Y	Z
a. Frictional (G88B)					
1) Maintenance - Tool rubs surface	42-126 Kpsi yield (316SS) @ 2 ft/sec	M1 dust 120 Kpsi @ 2 ft/sec TNT dust 190 Kpsi @ 2 ft/sec N5 dust 34 Kpsi @ 2 ft/sec	M1 (0) TNT (0.51 to 3.52) N5 (0)	1.0	1.0
2) Tramp material - Rubs surface	1-44 psi @ 45 ft/sec (7/16 in. bolt)		Undefined	1.0	10^{-4}
b. Impact (G88C)	1110 ft-lb/in.^{2} (7/16 in. bolt)				
1) Maintenance - Tool strikes surface	162 ft-lb/in.^{2} (12 in. crescent wrench)	M1 dust 3.8 ft-lb/in.^{2} steel/steel TNT dust 31.6 ft-lb/in.^{2} steel/steel	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibration - Impact loose parts or tramp material	Undefined		Undefined	1.0	10^{-4}
3) Fluid bed motor - Impact tramp or alumina against contaminated surface	Undefined		Undefined	1.0	1.0
4) Impingement - Impact from layer breaking free and striking contaminated	18,320 ft/min	M1 dust > 10,000 ft/min TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (0), TNT (0), N5 (0) TNT (1.07) N5 (0.02)	1.0	1.0

TABLE III-XXV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Material Contaminating Surface of Bed
(Gate G86A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. Thermal (G88D)					
1) Welding	3600°C	M1 dust 120°C (24hr)		1.0	1.0
2) Fire adjacent units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C		1.0	1.0
4) Residual heat	930°C			1.0	1.0
d. ESD (G88F)		M1 dust 0.013J			
1) Airveying material	0.025J	TNT dust 0.075J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
		N5 dust 0.075J			
2) Human	0.013J		M1 (-0.00) TNT (4.77) N5 (4.77)	10^{-2}	10^{-5}
e. Electrical power (G88G)					
1) Faulty electrical tools	Undefined	M1 dust 0.013J	Undefined	1.0	10^{-7}
2) Faulty instrumentation (press. and temp. indicators)	Undefined	TNT dust 0.075J	Undefined	1.0	10^{-4}
		N5 dust 0.075J			

TABLE III-XXV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Cloud from Propellant or Explosive Material in Bed (Gate G86C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable cloud present (G86D)				10^{-8}	
2. Initiation Stimuli				Y	Z
a. Impingement (G89B)					
1) Redirecting flow	18320 ft/min	M1 dust $\geq$ 10000 ft/min	M1 > 0 TNT (1.07) N5 (0.02)	1.0	1.0
2) Tramp material	18320 ft/min	TNT dust 38000 ft/min	M1 > 0 TNT (1.07) N5 (0.02)	1.0	1.0
3) Turbulent flow	18320 ft/min	N5 dust 1870 ft/min	M1 > 0 TNT (1.07) N5 (0.02)	1.0	1.0
4. Alumina bed material	18320 ft/min		M1 > 0 TNT (1.07) N5 (0.02)	1.0	1.0
b. Thermal (G89C)					
1) Welding	3600°C	M1 dust 150°C (1hr)		1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Normally occurring fire	3600°C	N5 dust 150°C		1.0	1.0
4) Residual Heat	930°C			1.0	1.0

TABLE III-XXV cont.

Summary of Controlling Factors which Influence the Initiation of Sufficient Flammable Cloud from Propellant or Explosive Material in Bed (Gate G86C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
c. ESD (G89E)					
1) Airveying material	0.025J	M1 dust 0.024J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
		N5 dust 0.075J			
d. Electrical Power (G89F)					
1) Faulty elect. tools	undefined		undefined	1.0	10^{-7}
2) Faulty instrumentation (temp or press indicator)	undefined		undefined	1.0	10^{-4}

TABLE III-XXVI

Summary of Controlling Factors which Influence the Initiation of Flammable Material Contaminating Surface of Cyclone Separator (Gate G98A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
i. Flammable material present on surface (G98B)				10^{-8}	
2. Initiation Stimuli				Y	Z
a. Frictional (G99B)					
1) Maintenance	42-126 Kpsi yield (316SS) @ 2 ft/sec	M1 dust 120 Kpsi @ 2 ft/sec TNT dust 190 Kpsi @ 2 ft/sec	M1 (0) TNT (0.51 to 3.52) N5 (0)	1.0	1.0
2) Tramp material	1-44 psi @ 32 ft/sec (7/16 in. bolt)	N5 dust 34 Kpsi @ 2 ft/sec	Undefined	1.0	10^{-4}
b. Impact (G99C)	555 ft-lb/in.^{2} (7/16 in. bolt)				
1) Maintenance	81.1 ft-lb/in.^{2} (12 in. crescent wrench)	M1 dust 3.8 ft-lb/in.^{2} steel/steel	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibration - Impact loose parts or tramp material	Undefined	TNT dust 31.6 ft-lb/in.^{2} steel/steel	Undefined	1.0	10^{-4}
3) Alumina bed material	Undefined	N5 dust 8.5 ft lb/in.^{2} steel/steel		1.0	1.0
4) Impingement - Impact from layer breaking free and striking contaminated surface	46,800 ft/min	M1 dust > 10,000 ft/min TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (0) TNT (0) N5 (0)	1.0	1.0
c. Thermal (G99D)					
1) Welding	3600°C	M1 dust 120°C (24 hr)	M1 (0), TNT (0), N5 (0)	1.0	1.0
2) Fire adj. units	3600°C	N5 dust 150 C TNT dust 230°C		1.0	1.0

TABLE III-XXVI cont.

Summary of Controlling Factors which Influence the Initiation of Flammable Material Contaminating Surface of Cyclone Separator (Gate G98A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY Y	PROBABILITY Z
c. 3) Residual heat	910°C	M1 - 120°C N5 dust 150°C TNT - 120°C	M1(0), TNT (0), N5 (0)	1.0	1.0
d. ESD (G99F)					
1) Airveying material	0.025J	M1 dust 0.013J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J N5 dust 0.075J	M1 (0.00) TNT (4.77) N5 (4.77)	10^{-2}	10^{-5}
e. Electrical Power (G99G)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}

TABLE III-XXVI cont.

SUMMARY OF CONTROLLING FACTORS WHICH INFLUENCE THE INITION OF FLAMMABLE CLOUD FROM PROPELLANT OR EXPLOSIVE WASTE IN CYCLONE SEPARATOR (GATE G98C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable cloud present (G98D)				10^{-8}	
2. Initiation Stimuli				Y	Z
a. Impingement (G100B)					
1) Redirecting flow	46,800 ft/min	M1 dust > 10,000 ft/min		1.0	1.0
2) Tramp material	46,800 ft/min	TNT dust 38,000 ft/min	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Turbulent flow	46,800 ft/min	N5 dust 18,700 ft/min		1.0	1.0
4) Alumina bed material	46,800 ft/min			1.0	1.0
b. Thermal (G100C)					
1) Welding	3600°C	M1 dust 150°C (1 hr)	M1 (0. TNT (0) N5 (0	1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Residual heat	910°C	N5 dust 150°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
c. ESD (G100E)					
1) Airveying material	0.025J	M1 dust 0.024J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J N5 dust 0.075J	M1 (-0.04) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
d. Electrical Power (G100F)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}

TABLE III -XXVII

Summary of Controlling Factors which Influence the Initiation of Flammable Material Contaminating Surface of Stack
(Gate G106A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* 10^{-8} Y	Z
1. Flammable Material					
2. Initiation Stimuli					
a. Frictional (G107B)					
1) Maintenance - Tool rubs surface	42-126 Kpsi yield (316SS) @ 2 ft/sec	M1 dust 120Kpsi @ 2 ft/sec) TNT dust 190Kpsi @ 2 ft/sec) N5 dust 34 Kpsi @ 2 ft/sec	M1 (0) TNT (0.51 to 3.52) N5 (0)	1.0	1.0
2) Tramp Material rubs surface	1-44 psi @ 45 ft/sec (7/16 in. bolt)		Undefined	1.0	10^{-4}
b. Impact (G107C)	1110 ft-lb/in.^{2} (7/16 in. bolt)				
1) Maintenance - Tool strikes surface	162 ft-lb/in.^{2} (12 in. crescent wrench)	M1 dust 3.8 ft-lb/in.^{2} steel/steel	M1 (0), TNT (0) N5 (0)	1.0	10^{-4}
2) Vibration - Impact loose parts or tramp material	Undefined	TNT dust 31.6 ft-lb/in.^{2} steel/steel	Undefined	1.0	10^{-4}
3) Alumina bed material	Undefined	N5 dust 8.5 ft-lb/in.^{2} steel/steel	Undefined	1.0	10^{-3}
4) Impingement - Impact from layer brea[illegible] free and striking c[illegible]taminated surface	46,800 ft/min	M1 dust > 10,000 ft/min TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (0) TNT (0) N5 (0)	1.0	10^{-3}

TABLE III-XXVII cont.

Summary of Controlling Factors which Influence the Initiation of Flammable Material Contaminating Surface of Stack (Gate G106A)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY Y	PROBABILITY Z
c. Thermal (G107D)					
1) Welding	3600°C	M1 dust 120°C (24 Hr.)	M1 (0)	1.0	1.0
2) Fire adj. units	3600°C	TNT dust 230°C	TNT (0)	1.0	1.0
3) Residual heat	910°C	N5 dust 150°C	N5 (0)	1.0	1.0
d. ESD (G107F)					
1) Airveying material	0.025J	M1 dust 0.013J	TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J N5 dust 0.075J	M1 (0.00) TNT (4.77) N5 (4.77)	10^{-2}	10^{-5}
e. Electrical power (G107G)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}

TABLE III-XXVII cont.

Summary of Controlling Factors which Influence the Initiation of Flammable Cloud from Propellant or Explosive Waste in Stack
(Gate 106C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable cloud present (G106D)				10^{-8}	
2. Initiation Stimuli				Y	Z
a. Impingement (G108B)					
1) Redirecting flow	46,800 ft/min	M1 dust > 10,000ft/min		1.0	10^{-3}
2) Tramp material	46,800 ft/min	TNT dust 38,000 ft/min	M1 (0) TNT (0) N5 (0)	1.0	10^{-3}
3) Turbulent flow	46,800 ft/min	N5 dust 18,700 ft/min		1.0	10^{-3}
4) Alumina bed material	46,800 ft/min			1.0	10^{-3}
b. Thermal (G108C)					
1) Welding	3600°C	M1 dust 150°C (1 hr)		1.0	10^{-5}
2) Fire adj. units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	1.0
3) Residual heat	910°C	N5 dust 150°C		1.0	1.0
c. ESD (G108E)					
1) Airveying material	0.025J	M1 dust 0.024J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013J	TNT dust 0.075J	M1 (0.85(TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
		N5 dust 0.075J			
d. Electrical Power (G108F)					
1) Faulty electrical tools	Undefined		Undefined	1.0	10^{-7}

TABLE III-XXXVII

Summary of Controlling Factors Which Influence the Initiation of Sufficient Flammable Fuel Oil in Hopper

(Gate G1D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Fuel Oil Present (G3G)				10^{-15}	
2. Initiation Stimuli				Y	Z
A. Thermal (G5B)					
1) Welding	3500°C	210°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C	210°C	0	1.0	10^{-7}
3) Residual Heat	60°C	210°C	2.50	10^{-7}	10^{-4}
B. ESD (G5C)					
1) Airveying material	0.025 J	0.002 J	0	1.0	10^{-5}
2) Human	0.013 J	0.002 J	0	1.0	10^{-8}
C. Electrical Power (G5D)					
1) Faulty electric tools	Undefined	0.002 J	Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined	0.002 J	Undefined	1.0	10^{-5}

TABLE III-XXVIII cont.

Summary of Controlling Factors Which Influence the Initiation of Flammable Material Contaminating the Surface of the Hopper

(Gate G1G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
				10^{-4} Y	Z
1. Flammable material present on surface (ZG1G)					
2. Initiation Stimuli					
A. Impact (G6B)					
1) Maintenance	870 ft-lb/in^2 (7/16" bolt) 127 ft-lb/in^2 (12" Cres. Wrench	M1 dust 3.8 ft-lb/in^2 S/S	M1 0, TNT 0, N5 0	1.0	10^{-4}
2) Vibration - loose parts	Undefined	TNT dust 31.6 ft-lb/in^2 S/S	Undefined	1.0	10^{-4}
3) Tramp material	102,000 ft-lb/in^2 (7/16" bolt)	N5 dust 8.5 ft-lb/in^2 S/S	M1 0 TNT 0 N5 0	1.0	10^{-4}
B. Frictional (G6C)					
1) Maintenance	42-126 Kpsi at 2 ft/sec	M1 dust 120 Kpsi at 2 ft/sec TNT dust 190 Kpsi at 2 ft/sec	M1 0 TNT (0.51 to 3.52) N5 0	1.0	1.0
2) Tramp material	42-126 Kpsi at undefined fps	N5 dust 3- Kpsi at 2 ft/sec	Undefined	1.0	10^{-4}
C. Thermal (G6D)					
1) Welding	3600°C	M1 dust 120°C (24 hrs)	M1 (0) TNT (0) N5 (0)	1.0	1.0
2) Fire Adjacent Units	3600°C	TNT dust 230°C		1.0	10^{-3}
3) Residual Heat	60°C	N5 dust 150°C	M1 (1) TNT (2.8) N5 (1.5)	10^{-5}	1.0
D. ESD (G6E)					
1) Airveying material	0.025 J	M1 dust 0.013 J	M1 0 TNT (2.00) N5 (2.00)	1.0	10^{-5}

TABLE III- XXVIII cont.

Summary of Controlling Factors Which Influence the Initiation of Flammable Material Contaminating the Surface of the Hopper

(Gate G1G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
2) Human	0.013 J	M1 0.013J TNT dust 0.075 J N5 dust 0.075 J	M1 (0.00) TNT (4.77) N5 (4.77)	1.0	10^{-5}
E. Electric Power (G6F)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined		Undefined	1.0	10^{-4}

TABLE III-XXVIII cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Cloud From Propellant at Explosive Waste in Hopper

(Gate C1J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Cloud Present (ZG1J)				10^{-5}	
2. Initiation Stimuli				Y	Z
A. Impingement (G7B)					
1) Condensed or particulate material	150 ft/min	M1 dust >10,000 ft/min TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (> 65) TNT (252.33) N5 (123.67)	10^{-16}	1.0
2) Contaminated tramp material	150 ft/min		M1 (>65.67) TNT (252.33) N5 (123.67)	10^{-16}	10^{-4}
B. Thermal (G7C)					
1) Welding	3600°C	M1 dust 150°C (1 hr) TNT dust 230°C N5 dust 150°C	M1 (0), N5 (0), TNT (0),	1.0	10^{-5}
2) Fire Adjacent Units	3600°C			1.0	10^{-7}
3) Residual Heat	60°C		M1 (1.50) TNT (2.83) N5 (1.50)	10^{-6}	10^{-4}
C. ESD (G7D)					
1) Airveying material	0.025 J	M1 dust 0.024 J TNT dust 0.075 J N5 dust 0.076J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-4}
2) Human	0.013 J		M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
D. Electrical Power (G7E)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined		Undefined	1.0	10^{-4}

* Material Response listed refers to general initiation mode, e.g., ESD and not specific initiation mode, e.g., Human ESD.

TABLE III-XXVIII cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Natural Gas in Hopper

(Gate G2C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Natural Gas Present (G3A)				10^{-16}	
2. Initiation Stimuli				Y	Z
A. Thermal (G8B)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C	482°C	0	1.0	10^{-7}
3) Residual Heat	60°C	482°C	7.03	10^{-10}	10^{-4}
B. ESD (G8C)					
1) Airveying Material	0.025 J	0.00047 J	0	1.0	10^{-5}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-8}
C. Electrical Power (G8D)					
1) Faulty Electric Tools	Undefined	0.00047 J	Undefined	1.0	10^{-7}
2) Faulty Electric Instruments	Undefined	0.00047 J	Undefined	1.0	10^{-4}

TABLE III-XXIX

Summary of Controlling Factors Which Influence The Initiation of Sufficient Fuel Oil in Charger

(Gate G15D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Fuel Oil Present in Cyclones (G17G)				10^{-11}	
2. Initiation Stimuli				Y	Z
A. Thermal (G19B)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C	210°C	0	1.0	10^{-4}
3) Residual Heat	200°C	210°C	0	10^{-1}	10^{-4}
4) Overheated Bearings	1500°C	210°C	0	1.0	10^{-4}
B. ESD (G19C)					
1) Airveying Material	0.025 J	0.002 J	0	1.0	10^{-5}
2) Human	0.013 J	0.002 J	0	1.0	10^{-8}
C. Electrical Power (G19D)					
1) Faulty electric tools	Undefined	0.002 J	Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined	0.002 J	Undefined	1.0	10^{-4}
3) Faulty electric installation	Undefined	0.002 J	Undefined	1.0	10^{-4}

TABLE III-XXIX cont.

Summary of Controlling Factors Which Influence The Initiation of Flammable Material on Surface of Charger

(Gate G15G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
				10^{-4}	
				Y	Z
1. Flammable Material Present on Surface (ZG15G)					
2. Initiation Stimuli					
A. Impact (G20B)					
1) Maintenance	350 ft-lb/in^2 (7/16" bolt) 51.2 ft-lb/in^2 (12" Crescent Wrench	M1 dust 3.8 ft-lb/in^2 S/S	M1 (0), TNT (0), N5 (0), M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibrations loose parts	Undefined	TNT dust 31.6 ft-lb/in^2 S/S	Undefined	1.0	10^{-4}
3) Tramp material	16,200 ft-lb/in^2 (7/16" bolt)	N5 dust 8.5 ft-lb/in^2 S/S	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
B. Frictional (G20C)					
1) Maintenance	42-126 Kpsi at 2 ft/sec	M1 dust 120 Kpsi at 2 ft/sec	M1 (0) TNT (0.51 to 3.52 N5 (0)	1.0	1.0
2) Tramp material	42-126 Kpsi at undefined fps	TNT dust 190 Kpsi at 2 ft/sec	Undefined	1.0	10^{-4}
3) Contains mechanical parts	42-126 Kpsi at undefined fps	N5 dust 34 Kpsi at 2 ft/sec	Undefined	1.0	10^{-4}
C. Thermal (G20D)					
1) Welding	3600°C	M1 dust 120°C (24 hours)	M1 (0) TNT (0) N5 (0)	1.0	1.0
2) Fire adjacent units	3600°C	TNT dust 230°C		1.0	1.0
3) Residual heat	200°C	N5 dust 150°C	M1 (0) TNT (0.15) N5 (0)	1.0	1.0

* Material Response listed refers to general initiation mode, e.g., ESD and not specific initiation mode, e.g., Human ESD.

TABLE III-XXIX cont.

Summary of Controlling Factors Which Influence The Initiation of Flammable Material on Surface of Charger

(Gate G15G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
4) Overheated bearing (motor)	1500°C		M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
D. ESD (G20E)					
1) Airveying material	0.025 J	M1 dust 0.013 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013 J	TNT dust 0.075 J N5 paste dust 0.075 J	M1 (0.00) TNT (4.77) N5 (4.77)	1.0	10^{-5}
E. Electrical Power (G20F)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined		Undefined	1.0	10^{-4}

TABLE III-XXIX cont.

Summary of Controlling Factors Which Influence The Initiation of Flammable Cloud From Propellant or Explosive Waste in Charger

(Gate G15J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Cloud Present (ZG15J)				10^{-5}	
				Y	Z
2. Initiation Stimuli					
A. Impingement (G21B)					
1) Condensed or particulate material	150 ft/min	M1 dust >10,000 ft/min	M1 (>65.67) TNT (252) N5 (124)	10^{-16}	1.0
2) Contaminated tramp material	150 ft/min	TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (>65.67) TNT (252) N5 (124)	10^{-16}	10^{-4}
B. Thermal (G21C)					
1) Welding	3600°C	M1 dust 150°C (1 hr)	M1 (0), N5 (0), TNT (0),	1.0	10^{-5}
2) Fire adjacent unit	3600°C	TNT dust 230°C	M1 (0), TNT(0.15)	1.0	10^{-4}
3) Residual heat	200°C	N5 dust 150°C	N5 (0), TNT (0), N5 (0)	1.0	10^{-4}
4) Overheated bearings	1500°C		M1 (0)	1.0	10^{-4}
C. ESD (G21D)					
1) Airveying material	0.025 J	M1 dust 0.024 J TNT dust 0.075 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013 J	N5 dust 0.075 0.075 J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
D. Electrical Power (G21E)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined		Undefined	1.0	10^{-4}
3) Faulty electric installation	Undefined		Undefined	1.0	10^{-4}

TABLE III-XXIX cont.

Summary of Controlling Factors Which Influence The Initiation of Natural Gas in Charger

(Gate G16C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Natural Gas Present in Cyclones (G17A)				10^{-12}	
2. Initiation Stimuli					
A. Thermal (G22B)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	10^{-4}
3) Residual heat	200°C	482°C	+1.41	10^{-6}	10^{-4}
4) Overheated bearing	1500°C	482°C	0	1.0	10^{-4}
B. ESD (G22C)					
1) Airveying material	0.025 J	0.00047 J	0	1.0	10^{-5}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-8}
C. Electrical Power (G22D)					
1) Faulty electric tools	Undefined	0.00047 J	Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined	0.00047 J	Undefined	1.0	10^{-4}
3) Faulty electric installation	Undefined	0.00047 J	Undefined	1.0	10^{-4}

TABLE III-XXX

Summary of Controlling Factors Which Influence The Initiation of Sufficient Fuel Oil in Furnace

(Gate 29D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Sufficient Flammable Fuel Oil is Present (G31A)				10^{-8}	
2. Initiation Stimuli				Y	Z
A. Thermal (G34B)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire Adjacent Units	3600°C	210°C	0	1.0	10^{-10}
3) Residual heat	1000°C	210°C	0	1.0	10^{-4}
4) Normally occurring fire	3600°C	210°C	0	1.0	1.0
B. ESD (G34C)					
1) Human	0.013 J	0.002 J	0	1.0	10^{-8}
2) Airveying material	0.025 J	0.002 J	0	1.0	10^{-5}
3) Flowing fuel oil	Undefined	0.002 J	Undefined	10^{-4}	10^{-5}
4) Flowing pilot gas	Undefined	0.002 J	Undefined	10^{-4}	10^{-5}
C. Electrical Power (G34D)					
1) Faulty electric tools	Undefined	0.002 J	Undefined	1.0	10^{-4}
2) Faulty electric instruments	Undefined	0.002 J	Undefined	1.0	10^{-7}

TABLE III-XXX cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Material Contaminating Surface of Furnace

(Gate 29G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Sufficient Flammable Material Present on Surface (G33A)				10^{-7}	
2. Initiation Stimuli				Y	Z
A. Impact (G35B)					
1) Maintenance	280 ft-lb/in^2 (7/16" bolt) 41 ft-lb/in^2 (12" crescent wrench)	M1 dust 3.8 ft-lb in^2 S/S	M1 0 TNT 0 N5 0	1.0	10^{-4}
2) Vibration - loose parts	Undefined	TNT dust 31.6 ft-lb/in^2 S/S	Undefined	1.0	10^{-4}
3) Tramp material	37.9 ft-lb/in^2 (7/16" bolt)	N5 dust 8.5 ft-lb/in^2 S/S	M1 (0), TNT(0.17) N5 (C)	1.0	10^{-4}
B. Frictional (G35C)					
1) Maintenance	42-126 Kpsi at 2 ft/sec	M1 dust 120 Kpsi at 2 ft/sec	M1 (0) TNT (0.51 to 3.52) N5 (0)	1.0	10^{-4}
2) Tramp material	42-126 Kpsi at undefined fps	TNT dust 190 Kpsi at 2 ft/sec N5 dust 34 Kpsi at 2 ft/sec	Undefined	1.0	10^{-4}
C. Thermal (G35D)					
1) Welding	3600°C	M1 dust 120°C (24 Hrs)		1.0	10^{-4}
2) Fire adjacent units	3600°C	TNT dust 230°C	M1 (0) TNT (0) N5 (0)	1.0	10^{-10}
3) Residual heat	1000°C	N5 dust 150°C		1.0	10^{-4}
4) Normally occuring fire	3600°C			1.0	1.0

TABLE III-XXX cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Material Contaminating Surface of Furnace

(Gate 29G)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
D. ESD (G35E)					
1) Human	0.013 J	M1 dust 0.013 J	M1 (0.00) TNT (4.77) N5 (4.77)	1.0	10^{-5}
2) Airveying material	0.025 J	TNT dust 0.075 J	M1 (-0.00) TNT (2.00) N5 (2.00)	1.0	10^{-5}
3) Flowing fuel oil	Undefined	N5 paste dust 0.075 J	Undefined	10^{-4}	10^{-5}
4) Flowing pilot gas	Undefined		Undefined	10^{-4}	10^{-5}
E. Electrical Power (G35F)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-4}
2) Faulty electric instruments	Undefined		Undefined	1.0	10^{-7}

TABLE III-XXX cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Cloud From Propellant or Explosive Waste in Furnace

(Gate G29J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY* Y	PROBABILITY* Z
1. Sufficient Flammable Cloud Present (G33C)				10^{-8}	
2. Initiation Stimuli					
A. Impingement (G36B)					
1) Condensed or particulate material	460 ft/min	M1 dust >10,000 ft/min; TNT dust 38,000 ft/min; N5 paste dust 18,700 ft/min	M1 (>20.74) TNT (81.61) N5 (39.65)	10^{-16}	1.0
2) Contaminated tramp material	460 ft/min		M1 (>20.74) TNT (81.61) N5 (39.65)	10^{-16}	10^{-4}
B. Thermal (G36C)					
1) Welding	3600°C	M1 dust 150°C (1 hour); TNT dust 230°C; N5 paste dust 150°C	M1 (0) TNT (0) N5 (0)	1.0	10^{-5}
2) Fire adjacent unit	3600°C			1.0	10^{-10}
3) Residual heat	1000°C			1.0	10^{-4}
4) Normally occurring fire	3600°C			1.0	1.0
C. ESD (G36D)					
1) Human	0.013 J	M1 dust 0.024 J; TNT dust 0.075 J; N5 paste dust 0.075 J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
2) Airveying material	0.025 J		M1 (-0.04) TNT (2.00) N5 (2.00)	1.0	10^{-5}
3) Flowing fuel oil	Undefined		Undefined	10^{-4}	10^{-5}
4) Flowing pilot gas	Undefined		Undefined	10^{-4}	10^{-5}

TABLE III-XXX cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Cloud From Propellant or Explosive Waste in Furnace

(Gate G29J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
D. Electrical Power (G35E)		M1 0.024J			
1) Faulty electric tools	Undefined	TNT 0.075J	Undefined	1.0	10^{-4}
2) Faulty electric instruments	Undefined	N5 0.075J	Undefined	1.0	10^{-7}

TABLE III-XXX cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Natural Gas in Furnace

(Gate G30C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
				Y	Z
1. Sufficient Flammable Natural Gas is Present (G31A)				10^{-8}	
2. Initiation Stimuli					
A. Thermal (G37B)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	10^{-10}
3) Residual heat	1000°C	482°C	0	1.0	10^{-4}
4) Normally occurring fire	3600°C	482°C	0	1.0	1.0
B. ESD (G37C)					
1) Airveying material	0.025 J	0.00047 J	0	1.0	10^{-8}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-5}
3) Flowing fuel oil	Undefined	0.00047 J	Undefined	10^{-4}	10^{-5}
4) Flowing pilot gas	Undefined	0.00047 J	Undefined	10^{-4}	10^{-5}
C. Electrical Power (G37D)					
1) Faulty electric tools	Undefined	0.00047 J	Undefined	1.0	10^{-4}
2) Faulty electric instruments	Undefined	0.00047 J	Undefined	1.0	10^{-7}

TABLE III-XXXI

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Material Contaminating Surface of Stack

(Gate G44C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Material Present on Surface (G48A)				10^{-11}	
2. Initiation Stimuli				Y	Z
A. Impact (G50B)					
1) Maintenance - Tool strikes surface	1480 ft-lb/in^2 (7/16" bolt) 216 ft-lb/in^2 (12" crescent wrench)	M1 dust 3.8 ft-lb/in^2 S/S	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
2) Vibration - loose parts	Undefined	TNT dust 31.6 ft-lb/in^2 S/S	Undefined	1.0	10^{-4}
3) Tramp material - Strikes surface	580 ft-lb/in^2	N5 dust 8.5 ft-lb/in^2 S/S	M1 (0), TNT (0), N5 (0)	1.0	10^{-4}
B. Frictional (G50C)					
1) Maintenance - Tool rubs surface	42-126 Kpsi at 2 ft/sec	M1 dust 120 Kpsi at 2 ft/sec	M1 (0) TNT [illegible] N5 [illegible]	1.0	1.0
2) Tramp material - Rubs surface	42-126 Kpsi at undefined fps	TNT dust 190 Kpsi at 2 ft/sec N5 dust 34 Kpsi at 2 ft/sec	Unde[illegible]	1.0	10^{-4}
C. Thermal (G50D)					
1) Welding	3600°C	M1 dust 120°C (24 Hrs)	M1 (0) TNT (0) N5 (0)	1.0	1.0
2) Fire adjacent units	3600°C	TNT dust 230°C		1.0	10^{-4}
3) Residual heat	800°C	N5 dust 150°C		1.0	1.0

TABLE III-XXXI cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Material Contaminating Surface of Stack

(Gate G44C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY	
D. ESD (G50E)					
1) Airveying material	0.025 J	M1 dust 0.013 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013 J	TNT dust 0.075 J	M1 (0.00) TNT (4.77) N5 (4.77)	1.0	10^{-5}
		N5 paste dust 0.075 J			
E. Electrical Power (G50F)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined		Undefined	1.0	10^{-4}

TABLE III-XXXI

Summary of Controlling Factors Which Influence The Initiation of Sufficient Fuel Oil in Stack

(Gate G44D)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable fuel oil is present (G46G)				10^{-12}	
				Y	Z
2. Initiation Stimuli					
A. Thermal (G49B)					
1) Welding	3600°C	210°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	210°C	0	1.0	10^{-8}
3) Residual heat	800°C	210°C	0	1.0	10^{-4}
B. ESD (G49C)					
1) Airveying material	0.025 J	0.002 J	0	1.0	10^{-5}
2) Human	0.013 J	0.002 J	0	1.0	10^{-8}
C. Electrical Power (G49D)					
1) Faulty electric tools	Undefined	0.002 J	Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined	0.002 J	Undefined	1.0	10^{-4}

TABLE III-XXXI cont.

Summary of Controlling Factors Which Influence The Initiation of Sufficient Flammable Cloud From Propellant or Explosion Waste in Stack

(Gate G44J)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Cloud Present (G48B)				10^{-12}	
2. Initiation Stimuli				Y	Z
A. Impingement (G51B)					
1) Condensed or particulate material	1800 ft/min	M1 dust >10,000 ft/min TNT dust 38,000 ft/min N5 dust 18,700 ft/min	M1 (>4.56) TNT (20.11) N5 (9.39)	10^{-16}	1.0
2) Contaminated tramp material	1800 ft/min		M1 (>4.56) TNT (20.11) N5 (9.39)	10^{-16}	10^{-4}
B. Thermal (G51C)					
1) Welding	3600°C	M1 dust 150°C (1 hr)	M1 (0) TNT (0) N5 (0)	1.0	10^{-5}
2) Fire adjacent units	3600°C	TNT dust 230°C		1.0	10^{-8}
3) Residual heat	800°C	N5 dust 150°C		1.0	10^{-4}
C. ESD (G51D)					
1) Airveying material	0.025 J	M1 dust 0.024 J	M1 (0) TNT (2.00) N5 (2.00)	1.0	10^{-5}
2) Human	0.013 J	TNT dust 0.075 J N5 dust 0.075J	M1 (0.85) TNT (4.77) N5 (4.77)	10^{-4}	10^{-8}
D. Electric Power (G51E)					
1) Faulty electric tools	Undefined		Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined		Undefined	1.0	10^{-4}

TABLE III-XXXI

Summary of Controlling Factors Which Influence The Initiation of Sufficient Natural Gas in Stack

(Gate G45C)

DESCRIPTION	PROCESS POTENTIAL	MATERIAL RESPONSE	SAFETY MARGIN	PROBABILITY*	
1. Flammable Natural Gas is Present (G46A)				10^{-12}	
2. Initiation Stimuli				Y	Z
A. Thermal (G52B)					
1) Welding	3600°C	482°C	0	1.0	10^{-5}
2) Fire adjacent units	3600°C	482°C	0	1.0	10^{-8}
3) Residual heat	800°C	482°C	0	1.0	10^{-4}
B. ESD (G52C)					
1) Airveying material	0.025 J	0.00047 J	0	1.0	10^{-5}
2) Human	0.013 J	0.00047 J	0	1.0	10^{-5}
C. Electrical Power (G52D)					
1) Faulty electric tools	Undefined	0.00047 J	Undefined	1.0	10^{-7}
2) Faulty electric instruments	Undefined	0.00047 J	Undefined	1.0	10^{-4}

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